Overweight and obesity in primary-school children

A surveillance system for policy-making in Europe from 2007 onwards

Trudy M.A. Wijnhoven


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Thesis

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ABSTRACT

Background

As a follow-up to the European Ministerial Conference on Counteracting Obesity convened in 2006 in Turkey, the European Childhood Obesity Surveillance Initiative (COSI) was launched by the Regional Office for Europe of the World Health Organization (WHO). COSI, a collaboration between WHO and interested Member States, aims to monitor the magnitude of overweight and obesity among primary-school children in European countries, to allow intercountry comparisons and to identify regional differences for informed policy-making. It collects at regular intervals data on weight and height of primary-school children and on their nutrition and physical activity behaviours, as well as on school environmental characteristics supportive to healthy nutrition and physical activity.

Methods

The research described in this PhD thesis is based on the data collected in the first two COSI rounds by 12 European countries in school year 2007/2008 and by 13 European countries in school year 2009/2010. Nationally representative samples of children aged 6–9 years were drawn, whereby a majority of the countries applied a two-stage school-based cluster sampling approach.

A total of 168 832 children in school year 2007/2008 and 224 920 children in school year 2009/2010 were included in the anthropometric intercountry data analyses. Children's weight and height were measured by trained examiners using standardized procedures. Participating countries were allowed to adhere to their local legal requirements by specified deviations from standardized procedures, such as in types of clothing worn by the children during weight and height measurements. For each country, the prevalence of overweight and obesity, as well as mean Z-scores of anthropometric indices of height, weight and body mass index (BMI) were computed.

The characteristics included in the analyses on the school environment referred to the frequency of physical education lessons, the availability of school playgrounds, the possibility to obtain food items and beverages on the school premises, and the organization of school initiatives to promote a healthy lifestyle. The school form was usually completed by the school principal or the teachers involved with the sampled classes. Data from 1831 schools in school year 2007/2008 and from 2045 schools in school year 2009/2010 were used. For each school, a school nutrition environment score (range: 0–1) was determined whereby higher scores correspond to higher support for a healthy school nutrition environment and the mean of the children's BMI-for-age Z-scores calculated.

Five countries in school year 2007/2008 provided children's data on 13 health-risk behaviours related to breakfast and food consumption frequency, physical activity, screen

time and sleep duration (n = 15 643). These data were reported by the caregivers alone or jointly with their child. For each country, the prevalence of the risk behaviours was estimated, and associations between them and overweight and obesity examined by multilevel logistic regression analyses.

Results

In both school years, a wide range in overweight and obesity prevalence estimates was found that differed significantly by country, as well as by European region. In all countries, the percentage of overweight children was about 20% or more (range: 18–57%), and the percentage of obese children was 5% or more (range: 5–31%). The findings suggest the presence of a north–south gradient with the highest overweight and obesity prevalence estimates found in southern European countries. Furthermore, changes in mean BMI-for-age Z-scores (range: from –0.21 to +0.14) and prevalence of overweight (range: from –9.0% to +6.2%) from school year 2007/2008 to school year 2009/2010 varied significantly among countries, whereas a period of two years is considered too short to identify these developments. The clothes-adjusted overweight prevalence estimates were lower by as much as 12% than the unadjusted estimates. Monthly BMI-for-age Z-score values within countries did not show systematic seasonal effects.

Large between-country differences were observed in both school years in the availability of food items or beverages on the school premises (e.g., fresh fruit could be obtained in 12–95% of schools) and in the organization of initiatives to promote a healthy lifestyle in the selected classes (range: 42–97%). The provision of physical education lessons and the availability of school playgrounds were more uniformly present across the countries (range: 76–100%). A large variation was also seen in school nutrition environment scores (range: 0.30–0.93) whereby countries with a low score (< 0.70) graded less than three out of five characteristics as supportive. High-score countries showed more often than low-score countries a combined absence of cold drinks containing sugar, sweet snacks and salted snacks on the school premises.

The prevalence of all 13 health-risk behaviours differed significantly across countries. For instance, the percentage of children who ate 'foods like candy bars or chocolate' > 3 days/week ranged from 2.2% to 63.4%; this figure ranged from 1.1% to 46.5% for those who ate 'foods like potato chips (crisps), corn chips, popcorn or peanuts' > 3 days/week. The range for children who did not have breakfast every day was between 4.4% and 32.5%, and from 4.8% to 35.0% for those who did not play outside ≥ 1 hour/day. Not having breakfast daily and spending screen time ≥ 2 hours/day were clearly positively associated with obesity. The same was true for eating 'foods like pizza, French fries, hamburgers, sausages or meat pies' > 3 days/week and playing outside < 1 hour/day. While a combination of multiple less favourable physical activity behaviours was clearly positively associated with obesity, a

combination of the presence of multiple unhealthy eating behaviours did not lead to higher odds of obesity.

Conclusions

The results found in both COSI school years show that overweight and obesity among 6–9-year-old children are a serious public health concern, especially in southern European countries, and show the need for accelerated efforts to prevent excess body weight early in life by all participating countries. It was possible to detect relevant changes within a period of two years but to identify clear trends within countries, a longer time interval is necessary. The data on the school nutrition environment and the children's health-risk behaviours may assist policy-makers in monitoring their national policies targeting school settings and childhood obesity. In particular, promoting physical activity-related and discouraging sedentary behaviours among schoolchildren in the context of obesity preventive interventions seem to be essential.

CONTENTS

ABBREVIATIONS

ANOVA	analysis of variance
BEL	Belgium
BGR	Bulgaria
BMI	body mass index
BMI/A	body mass index-for-age
CEHAPE	Children's Environment and Health Action Plan
CI	confidence interval
COSI	Childhood Obesity Surveillance Initiative (study)
CV	coefficient of variation
CZE	Czech Republic
DHS	Demographic and Health Survey
DNK	Denmark
EASO	European Association for the Study of Obesity
EC	European Commission
ECO	European Congress on Obesity
ENERGY	EuropeaN Energy balance Research to prevent excessive weight Gain among Youth (project)
ESP	Spain
EU	European Union
EURO-PREVOB	Consortium for the prevention of obesity through effective nutrition and physical activity actions (project)
EURRECA	EURopean micronutrient RECommendations Aligned (network of excellence)
FAO	Food and Agriculture Organization of the United Nations
FFQ	food frequency questionnaire
GBR	United Kingdom of Great Britain and Northern Ireland
GRC	Greece
GSHS	Global school-based Student Health Survey
H/A	height-for-age
HBSC	Health Behaviour in School-aged Children (study)
HELENA	Healthy Lifestyle in Europe by Nutrition in Adolescence (project)
HUN	Hungary
IDEFICS	Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (project)
IOTF	International Obesity Task Force
IRL	Ireland

ISO	International Organization for Standardization
ITA	Italy
KLV	Royal Netherlands Society for Agricultural Sciences
LTU	Lithuania
LVA	Latvia
MGRS	Multicentre Growth Reference Study
MICS	Multiple Indicator Cluster Survey
MKD	The former Yugoslav Republic of Macedonia
MLT	Malta
NA	not applicable
NC	not calculated
NCD	noncommunicable disease
ND	not determined
NOPA	Nutrition, Obesity and Physical Activity (database)
NOR	Norway
NS	not significant
NWO	Netherlands Organisation for Scientific Research
OECD	Organisation for Economic Co-operation and Development
OR	odds ratio
PRT	Portugal
PSU	primary sampling unit
Q1	first quartile
Q3	third quartile
RIVM	Dutch National Institute for Public Health and the Environment
SD	standard deviation
SSU	secondary sampling unit
SVN	Slovenia
SWE	Sweden
SWOT	strengths, weaknesses, opportunities and threats
UNICEF	United Nations Children's Fund
W/A	weight-for-age
WGS	Wageningen Graduate Schools
WHA	World Health Assembly
WHO	World Health Organization
WUR	Wageningen University & Research Centre

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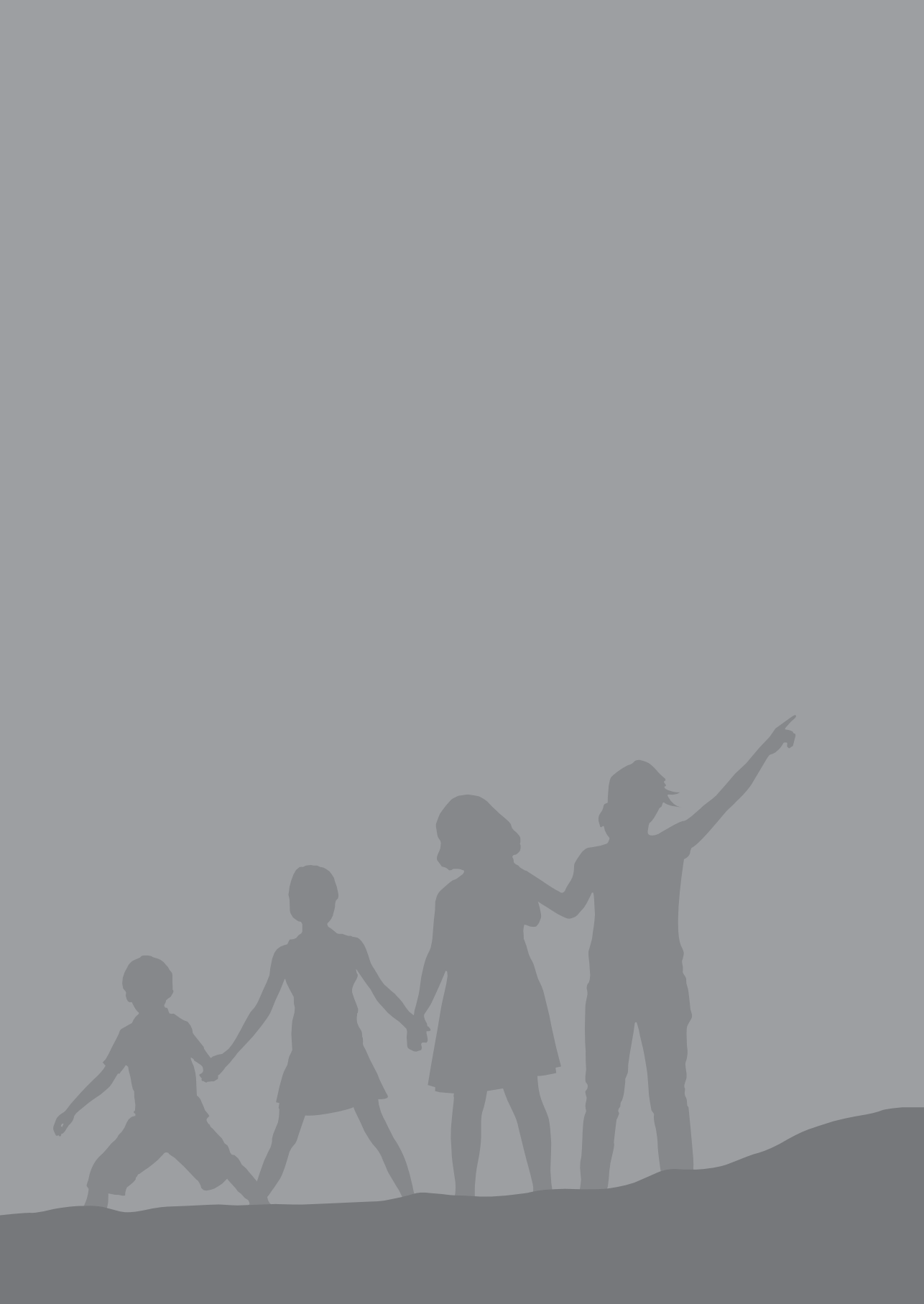
Introduction



The worldwide prevalence of obesity has more than doubled since 1980, and to date most of the world's populations live in countries where overweight and obesity lead to more deaths than underweight[1]. Childhood obesity is under-recognized as a public health issue, and this urgent and serious public health challenge should be addressed[2]. This chapter discusses the problem of childhood overweight, refers to the importance of monitoring childhood overweight levels and gives an overview of global and European policy frameworks addressing childhood overweight. Subsequently, it provides an introduction to the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI), which provides the framework for the research described in this thesis. This chapter ends by presenting the research objectives and the thesis outline.

PROBLEM OF CHILDHOOD OVERWEIGHT

Magnitude of the problem globally and in Europe

According to joint estimates of the United Nations Children's Fund (UNICEF), WHO and the World Bank, the number of overweight or obese under-five-year-old children increased globally from 32 million in 1990 to 42 million in 2013[3]. If current trends continue, the number of overweight or obese infants and young children globally will increase to 70 million by 2025, which is equivalent to approximately 11% of the world's population[3,4]. For the period 2007–2014, the prevalence of overweight children under five years of age in the WHO European Region is estimated to be 12.4%[5] (based on the 2006 WHO child growth standards[6]).

Age-standardized estimates of the prevalence of overweight among school-age children and adolescents below the age of 20 years for various subregions in the WHO European Region come from the Global Burden of Disease Study 2013, using both measured and self-reported data collected between 1980 and 2013[7]. The growth reference recommended by the former International Obesity Task Force (IOTF)[8] to define overweight was used for the derivation of the estimates. The estimated prevalence of overweight for boys and girls in central Asia is 19.9% and 20.6%, respectively. Similar estimates are given for central Europe (21.3% in boys and 20.3% in girls) and eastern Europe (19.0% in boys and 18.8% in girls). The estimated prevalence of overweight for boys and girls in western Europe is 24.2% and 22.0%, respectively. The range in the estimated prevalence of obesity for these four regions is 6.8–7.5% in boys and 5.9–6.4% in girls[7].

Health consequences of childhood overweight

Being overweight or obese during childhood increases the child's risk of being overweight or obese during adolescence[9,10], as well as during adulthood[9,11,12]. The findings of the longitudinal study done by Nader *et al*. suggest that 60% of children who are overweight

at age 2, 3 or 4.5 years and 80% of children who are overweight at age 7, 9 or 11 years are overweight at the age of 12 years[10]. According to the studies identified by Singh *et al*., overweight children are 2–10 times more likely to become overweight adults compared with normal-weight children[11].

Childhood obesity is commonly known to be associated with an increased risk of multiple comorbidities[9,12–17] and premature mortality in adult life[13–15], although it is not yet clear whether these associations reflect the tracking of body mass index (BMI) from childhood to adulthood or an independent level of risk[12,18,19]. However, a growing body of evidence also suggests that childhood overweight increases the risk of early onset of obesity-related health complications[12,13,18–32], which were once thought to be associated only with obesity among adults, such as diabetes mellitus type II[12,20–25], atherosclerosis[22,26,27], elevated blood pressure[12,21,22,24,28–31], non-alcoholic fatty liver disease[13,23–25,32] or hyperlipidemia[12,22,24–26,30,31]. The early occurrence of these diseases in childhood may considerably increase the burden on paediatric services in communities[33], as well as have important implications on children's future risk of noncommunicable diseases (NCDs)[13,34]. Moreover, metabolic and cardiovascular risk profiles tend to track from childhood to adulthood and will consequently increase future demand for health services[13,34,35].

Compared to healthy weight children, obese children are more likely to experience depressive episodes[21,25], suffer from body dissatisfaction[21,25,36], poor self-esteem[13,21,25,37] or migraines[38], and be diagnosed with orthopaedic problems[25] or asthmatic symptoms[39–41].

NCDs are currently the leading causes of death worldwide[34,42]. They accounted in 2012 for nearly 86% of deaths and 77% of disease burden in the WHO European Region[43]. The proportion of type II diabetes cases in adulthood attributable to a BMI value of > 21 kg/m^2 ranges from 68% to 84%, and the proportion of hypertensive disease cases attributable to an elevated BMI ranges from 56% to 64%[13]. Early interventions aimed at preventing childhood obesity thus represent important opportunities to reduce comorbidities and other long-term health consequences in children and the future burden of NCDs[2,34].

INTERNATIONAL POLICY FRAMEWORKS ADDRESSING CHILDHOOD OVERWEIGHT

A successful implementation of effective measures to counteract excess body weight in children depends on strong high-level political commitment by the government, full involvement of all governmental sectors and effective coordination[13]. International policy frameworks give direction and provide policy options and strategies, which governments may incorporate as appropriate into their national policies and action plans[44]. Another function is to facilitate global or region-wide action on this public health challenge of obesity[45].

Numerous international policy frameworks related to nutrition, physical activity and obesity have been endorsed by governments since the 1990s, which show the strong commitment by governments to keep these areas high on their political agendas. Examples of global and European policies and action plans are given below in chronological order, whereby specific references are made to the included obesity preventive actions in childhood.

Global policy frameworks

The 1992 *World Declaration and Plan of Action for Nutrition* provided the basis for the global development of nutrition policies and included achieving and maintaining health and nutritional well-being of all people as one of the four overall objectives[46].

The World Health Assembly (WHA) endorsed in 2002 resolution WHA55.25[47] on the *Global Strategy for Infant and Young Child Feeding*[48]. This global strategy states the rising incidences of overweight and obesity, besides undernourishment, among young children as a matter of serious concern.

Recognizing the heavy and growing burden of NCDs, the World Health Assembly in 2004 passed resolution WHA57.17[49] endorsing the WHO *Global Strategy on Diet, Physical Activity and Health*[50].

An Action Plan[51] for the 2000 *Global Strategy for the Prevention and Control of NCDs*[52], covering the period 2008–2013, was endorsed at the Sixty-first World Health Assembly in 2008[53]. In the context of the promotion of a healthy diet, the action plan includes two specific actions targeting children: (1) promotion and support of exclusive breastfeeding for the first six months of life and promotion of programmes to ensure optimal feeding for all infants and young children; and (2) preparation and putting in place a framework and/or mechanisms for promoting the responsible marketing of foods and non-alcoholic beverages to children, in order to reduce the impact of foods high in saturated fats, trans fatty acids, free sugars or salt[51].

As a next step, the First Global Ministerial Conference on Healthy Lifestyles and NCD Control was convened in Moscow, Russian Federation, on 28–29 April 2011[54]. The aim of this Conference was to raise political awareness about the importance and potential for prevention and control of NCDs and to place them higher on the global and national political agendas. The Conference ended with the endorsement of the *Moscow Declaration: commitment to act, way forward*[55], which was then subsequently endorsed by the Sixty-fourth World Health Assembly[56].

On 19–20 September 2011, the United Nations General Assembly convened a high-level meeting on the prevention and control of NCDs, with the participation of heads of state and government[57]. This was the second time that the General Assembly met on a health issue (first time was in 2001 on HIV/AIDS[58]). Among the immediate national priorities raised that are relevant for children were the reduction of the marketing of unhealthy foods and non-

alcoholic beverages to children and the production and promotion of more food products consistent with a healthy diet. The United Nations General Assembly adopted the *Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of NCDs* in which concerns were expressed on the rising levels of obesity, particularly among children and youth, in different regions[59].

The Sixty-fifth World Health Assembly adopted in 2012 a resolution[60] endorsing a *Comprehensive implementation plan on maternal, infant and young child nutrition*[61] that includes the global target of no increase in childhood overweight by 2025. One of the additional core indicators proposed and discussed at an informal WHO consultation with Member States in April 2015 for the Global Monitoring Framework on Maternal, Infant and Young Child Nutrition refers to the prevalence of overweight and obesity in school-age children and adolescents (5–18 years)[62].

To accelerate national efforts to address NCDs, in 2013 the Sixty-sixth World Health Assembly adopted a comprehensive global monitoring framework with 25 indicators and nine voluntary global targets for 2025[63]. One of the nine voluntary global targets for the prevention and control of NCDs to attain by 2025 is to halt the rise in obesity[63], whereby the prevalence of overweight and obesity in adolescents (defined according to the 2007 WHO growth reference[64]) is one of the 25 voluntary indicators to monitor. In addition, the Sixty-sixth World Health Assembly[63] also endorsed the WHO *Global Action Plan for the Prevention and Control of NCDs 2013–2020*[65].

The Second International Conference on Nutrition held in Rome, Italy, on 19–21 November 2014 was organized by the Food and Agriculture Organization of the United Nations (FAO) and WHO. It called on heads of state and government to agree on a new global framework to adequately address major nutrition challenges over the coming decades[44]. The outcome document of this Conference was the *Rome Declaration on Nutrition* in which the representatives acknowledge that different forms of malnutrition co-exist within most countries, and commit themselves to reverse the rising trends in overweight and obesity and reduce the burden of diet-related NCDs in all age groups[66].

European policy frameworks

Following the International Conference on Nutrition in 1992[46], the World Food Summit was convened in 1996[67] to renew the global commitment by heads of state and government to fight against hunger and food insecurity. As a follow-up, the WHO Regional Committee for Europe endorsed in 2000 the First Action Plan for Food and Nutrition Policy for the period 2000–2005[68,69].

At the Fourth Ministerial Conference on Environment and Health, convened in Budapest, Hungary, in June 2004[70], ministers committed themselves to implementing the Children's Environment and Health Action Plan (CEHAPE) for Europe[71] in their countries and adopted

the Conference Declaration[72]. CEHAPE emphasizes effective action for protecting children's health and one of its aims is to reduce the prevalence of overweight and obesity among children.

The *European Strategy for the Prevention and Control of NCDs*[73] was endorsed in 2006 by the WHO Regional Committee for Europe[74]. It promotes a comprehensive and integrated approach to tackling NCDs and addresses the obesogenic environments that have serious implications for obesity levels, particularly among children[73].

In order to facilitate region-wide action on the emerging public health challenge of obesity and place this issue high on government political agendas, the WHO Regional Office for Europe organized the WHO European Ministerial Conference on Counteracting Obesity in Istanbul, Turkey, in November 2006[75]. At the Conference, the WHO *European Charter on Counteracting Obesity* was adopted[76].

In February 2007, the European Commission (EC) adopted the white paper *A Strategy for Europe on Nutrition, Overweight and Obesity related health issues*, which sets out a wide range of proposals on how the European Union (EU) can tackle nutrition, overweight and obesity-related health issues[77]. This was preceded by a series of European Council resolutions, adopted in 1990[78], 2000[79], 2002[80], 2003[81], 2005[82] and 2006[83], emphasizing the development of actions in the field of nutrition, physical activity and counteracting obesity (particularly among children and adolescents).

Following the WHO European Ministerial Conference on Counteracting Obesity in 2006[75], WHO European Region Member States approved in September 2007 resolution EUR/RC57/R4[84], which endorses the *WHO European Action Plan for Food and Nutrition Policy 2007–2012*[85] and calls on Member States to develop and implement food and nutrition policies. Reversing the obesity trend in children is presented as one of the four goals of the Action Plan.

During the Fifth Ministerial Conference on Environment and Health, convened in Parma, Italy, in March 2010, a declaration and commitment to act were adopted[86]. Through these documents, participating governments agreed to implement national programmes to provide equal opportunities to each child by 2020 by ensuring, among others, opportunities for physical activity and a healthy diet.

Taking account of Members States' existing commitments, the *Action plan for implementation of the European Strategy for the Prevention and Control of NCDs 2012–2016* sharpens the focus on NCDs[43]. It was endorsed by the WHO Regional Committee for Europe in 2011[87] and includes the reduction of obesity as one of its outcome measures and the promotion of healthier diets via food pricing, labelling and marketing controls as one of its process measures. The marketing of processed foods, in particular to children, is noted in this context.

Health 2020 is the European health policy framework[88] adopted at the Sixty-second session of the WHO Regional Committee for Europe in 2012[89]. One of the four priority action

areas is to tackle NCDs cost-effectively through interventions aimed at modifying behavioural and lifestyle risk factors. Specific measures to prevent overweight in children are noted in the area of exposure to the marketing of foods high in saturated fat, trans fatty acids, free sugar or salt and the promotion of physical activity[88].

To revitalize and strengthen the political commitments made through the 2006 *European Charter on Counteracting Obesity*[76], a WHO European Ministerial Conference on Nutrition and NCDs in the Context of Health 2020 was convened on 4–5 July 2013 in Vienna, Austria[90]. One of the ministerial panel sessions was on childhood obesity and inequalities in the WHO European Region. The *Vienna Declaration on Nutrition and NCDs in the Context of Health 2020*[91] was a major output of the Conference and was subsequently adopted by the WHO Regional Committee for Europe at its Sixty-third session in September 2013[92].

Recognizing the growing health challenge for the EU of rising levels of overweight and obesity among children, an EU action plan focussing entirely on childhood obesity was prepared under the Irish EU Presidency in 2013 and adopted at a high-level meeting in February 2014 in Athens, Greece, under the Greek EU Presidency[93].

In September during the same year, a new *European Food and Nutrition Action Plan 2015–2020*[94] was endorsed by the WHO Regional Committee for Europe[95]. Among the voluntary targets included in the Action Plan are to halt the increase in obesity in general, and in the prevalence of overweight among children under five years of age in particular[94].

The promotion of healthy nutrition and physical activity throughout the life-course, in particular during childhood and adolescence, to combat overweight and obesity are specifically mentioned in the European child and adolescent health strategy covering the period 2015–2020[96]. Furthermore, related actions should be in line with the Vienna Declaration[91]. This European strategy was also approved at the Sixty-fourth session of the WHO Regional Committee for Europe in 2014[97].

MONITORING OF CHILDHOOD OVERWEIGHT LEVELS

In order for countries to transform the given international overarching policy documents into country-specific policies, the national situation needs to be analysed illustrating the problem[13]. The first step towards a national policy for preventing obesity is setting the scene, for example, by describing the current national prevalence of overweight and obesity, and assessing the dietary habits and level of physical activity in the population and subgroups that differ in age, sex, socioeconomic status and geographical area, and establishing country-specific goals based on survey data and nutrition and physical activity recommendations[13]. Compiling intercountry comparable data is essential to evaluate the achievement of targets and indicators set at the international level[13,50].

Importance of monitoring

Data collection is the core element of monitoring and surveillance systems. Disease monitoring may be described as the ongoing/continuous efforts directed at assessing the health and disease status of a given population; disease surveillance refers to a more active system implying that some form of directed action will be taken if the data indicate a disease level above a certain threshold or that a target such as 'halt the rise of obesity' has not been achieved[98–100]. As a result of surveillance activities, results may then be disseminated in order to inform which immediate or future actions for public health are to be taken[99].

The need for a public health surveillance system to monitor a health-related event is determined by a number of parameters[100], which are all present in the case of overweight and obesity in children[101]. These parameters refer to indices of frequency (i.e. prevalence and incidence), indices of severity (i.e. health consequences), disparities or inequities associated with childhood overweight, economic consequences, preventability, potential clinical course in the absence of an intervention and public interest[100,101].

National obesity surveillance systems can provide scientific data that are essential to informed decision making and developing appropriate public health action[13,102]. In addition, the data can be used to measure the burden of obesity in the population and monitor its trends over time; guide the planning, implementation, and evaluation of obesity preventive programmes; evaluate national strategies and policies; prioritize the allocation of health resources; and provide a basis for epidemiological research[100].

International obesity surveillance systems using a similar data collection methodology can provide the data that are essential to benchmarking of countries against global targets and making comparisons between countries[103].

Examples of existing monitoring systems in European countries

Population-based surveys can be used for surveillance purposes if repeated on a regular basis[102]. Within Europe, cross-sectional studies to survey the prevalence of overweight or obesity among children aged 0–9 years (which is the upper age limit of children used by WHO[104]) may be done within an international context whereby a similar research protocol is used or within a national or local context whereby a self-developed survey methodology is used.

Besides COSI, the country-comparable nationally representative surveys carried out among children in Europe are the demographic and health surveys (DHS)[105], which exist since 1984 and are implemented by ICF International, and the multiple indicator cluster surveys (MICS)[106], which exist since 1995 and were developed by UNICEF. Both surveys draw population-based samples and measure the weight and height of preschool children aged 0–4.9 years.

Country-specific surveys are population based or school based, and children's weight and height are either measured, self-reported by children or indicated by proxy respondents. Examples of these surveys repeated on a regular basis to monitor the trends of overweight

prevalence estimates in children are the Belgian Health Interview Survey (every 4–5 years since 1997)[107], the nationwide growth study in the Czech Republic (every 10 years since 1951)[108], the Survey of Living Conditions (yearly in 1997–2009) and Health Survey (yearly since 2010) in the Netherlands[109], the nationwide growth study in the Netherlands (every 10–15 years since 1955)[110], Health Survey for England (yearly since 1991)[111], the National Child Measurement Programme in England (yearly since school year 2006/2007)[112], the Scottish Health Survey (1995, 1998, 2003 and yearly since 2008)[113], the Welsh Health Survey (yearly since 2003)[114] and the Child Measurement Programme for Wales (yearly since school year 2011/2012)[115].

Challenges of intercountry comparisons

The WHO European Region is rich in data from nationally representative surveys that can be used for national monitoring purposes. Using these data for international monitoring purposes and comparisons across countries in the Region, however, can be a challenge owing to the use of different instruments[13,87]. The exceptions are DHS[105] and MICS[106] for children under five years of age.

Supplementary Table **1.1** gives an overview of nationally representative surveys in WHO European Member States[116] concluded in 2007 onwards (the year after the WHO European Ministerial Conference on Counteracting Obesity took place[75]), included preschool children within the age range of 0–5 years, and reported on their prevalence of overweight and/or obesity. Supplementary Table **1.2** gives a similar overview for surveys that included schoolchildren within the age range of 6–9 years. Country COSI publications are excluded from this overview. The listed surveys were identified by consulting the WHO Global Database on Child Growth and Malnutrition[117], searching the electronic literature in the PubMed online database[118] and by reviewing the English websites of the DHS[105] programme, the MICS[106] programme, the World Obesity Federation[119], the Organisation for Economic Co-operation and Development (OECD)[120], national research and academic institutions, and ministries of health.

For preschool children, DHS and MICS use the WHO 2006 growth standards[6] to define the prevalence of overweight and/or obesity, whereas the country-specific surveys use either the IOTF growth reference[8,121] or a national growth reference[122–124] (Supplementary Table **1.1**). The majority of country-specific surveys of schoolchildren used either the IOTF growth reference[8,121] or a national growth reference[122,123,125,126] to define the prevalence of overweight and/or obesity; only three surveys used the 2007 growth reference for school-aged children and adolescents recommended by WHO[64] (Supplementary Table **1.2**). The challenge with the use of different growth references to define overweight and obesity in children can be overcome when data are made available to international bodies. Yet, challenges exist due to the differences in age ranges, survey years and method of data collection (measured versus self-reported data).

WHO EUROPEAN CHILDHOOD OBESITY SURVEILLANCE INITIATIVE

The *European Charter on Counteracting Obesity* encourages the development of internationally comparable core indicators for inclusion in national health surveillance systems so that the resulting data can be used for advocacy, policy-making and monitoring purposes[76]. The first consultation with Member States in the process leading to the WHO European Ministerial Conference on Counteracting Obesity in 2006[75] discussed the lack of data among school-aged children and fragmented data when available, and expressed the need for a European-wide harmonized surveillance system on which obesity policy development within the Region could be based[127]. After the Conference, at which an outline of COSI was presented, the WHO Regional Office for Europe and 13 Member States started the development of COSI as a response to this need[128].

COSI aims to measure routinely trends in overweight and obesity in nationally representative samples of primary-school children (aged 6–9 years), in order to form a correct understanding of the progress of the epidemic in this population group and to permit intercountry comparisons within the European Region. The system is designed to be as simple as possible and should not demand a major investment of public resources. There is no intention to replace countries' existing health, anthropometric and dietary surveillance systems already in place or at the planning stage; on the contrary, the system should if possible be integrated with them. Although each country is free to develop a system that fits its local circumstances, it is however important that data are collected according to the common COSI protocol and contain the stipulated core items[128].

The core anthropometric measurements are body weight and body height, and the optional measurements are waist and hip circumferences. These measurements are made by examiners trained and standardized according to the WHO measurement techniques and the common COSI protocol. In addition, COSI employs a mandatory school form that collects information on a few school (environmental) characteristics such as: the frequency of physical education lessons, the availability of school playgrounds, the possibility to obtain food items and beverages on the school premises, and current school initiatives organized to promote a healthy lifestyle (healthy eating, physical activity). COSI also uses an optional family record form to gather information on a voluntary basis on simple indicators of the children's dietary intake and physical activity/inactivity patterns such as usual transport to school, membership of a sport or dancing club, time typically spent playing outside or watching television, or food frequency consumption[128].

The first COSI data collection took place during the school year 2007/2008 with 13 countries participating (Belgium (Flanders), Bulgaria, Cyprus, the Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden). The second round took place during the school year 2009/2010 with four new participating countries: Greece,

Hungary, Spain and the former Yugoslav Republic of Macedonia. An additional four countries (Albania, the Republic of Moldova, Romania and Turkey) joined the third data collection round (school year 2012/2013). The fourth COSI data collection round is planned for the school year 2015/2016[128].

RESEARCH OBJECTIVES

The objective of this PhD research was to learn from the experiences in the COSI data collection rounds 2007/2008 and 2009/2010 by exploring the data on the children's weight and height measurements and their nutrition and physical activity behaviour, as well as on the nutrition and physical activity environment in schools. The specific research questions were as follows.

1. What is the magnitude of the problem of overweight and obesity among primary-school children in European countries?
2. Does overweight and obesity prevalence differ by country and by European region?
3. Is it possible to notice a change in overweight and obesity prevalence in a country within a time interval of only 2–3 years?
4. Do factors related to the school nutrition environment or the child's behaviour play a role in the occurrence of overweight and obesity in European countries, and does the level of presence of these factors differ by country and by European region?
5. To what extent can flexible data collection procedures be part of a common European surveillance system and allow intercountry comparisons of overweight and obesity prevalence?

THESIS OUTLINE

Research questions 1 and 2 are addressed in both **Chapters 2 and 3**. **Chapter 2** presents the anthropometric results of the first COSI data collection round during school year 2007/2008 from 12 participating countries, whereas **Chapter 3** reports on the anthropometric results of the second COSI data collection round during school year 2009/2010 from 13 participating countries and on the change from school years 2007/2008 to 2009/2010 (*research question 3*).

Research question 4 is dealt with in **Chapters 4 and 5**. **Chapter 4** focuses on data that were collected on school environmental characteristics on nutrition and physical activity in the sampled primary schools by 10 countries in school year 2007/2008 and nine countries in school year 2009/2010. **Chapter 5** shows the findings of the optional COSI family record form applied by five countries in school year 2007/2008. In particular, the findings on the children's food consumption frequency, physical activity and sedentary behaviour are described.

The implementation level of two data collection practices for which the COSI protocol permitted flexibility is described in **Chapter 6** (*research question 5*). These practices concerned the types of clothing worn by children during weight and height measurements, clothes weight adjustments applied, timing of the survey and duration of data collection.

Finally, **Chapter 7** summarizes the main findings in the context of the five research questions, delves into some methodological issues related to the COSI study design, provides examples of COSI data use and finishes with some suggestions on how the currently established surveillance system could be enhanced.

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Supplementary Table 1.1 Nationally representative prevalence of overweight (including obesity) and obesity in preschool children based on surveys concluded in 2007* or later and represented by population-based data, by country

Country	Survey	Year	Age *(y)*	Overweight (including obesity)† *(%)*		Obesity‡ *(%)*	
				Boys	Girls	Boys	Girls
Based on measured weight and height							
Albania	DHS	2008/2009[117,129]	0–4	22.5	24.4	8.9	10.0
Armenia	DHS	2010[117,130]	0–4	20.7	15.9	8.1	5.6
Bosnia and Herzegovina	MICS	2011/2012[117,131]	0–4	17.6	18.6	7.1	5.4
England, GBR	Country	2007[132]	2, 3, 4, 5	29, 26, 28, 25§	25, 27, 28, 24§	14, 16, 13, 11§	14, 12, 13, 13§
		2008[133]	2, 3, 4, 5	29, 24, 25, 26§	18, 27, 21, 17§	17, 8, 9, 12§	9, 11, 9, 9§
		2009[134]	2, 3, 4, 5	22, 33, 35, 19§	33, 23, 25, 26§	8, 14, 16, 5§	16, 7, 8, 20§
		2010[135]	2, 3, 4, 5	25, 33, 25, 26§	19, 27, 25, 23§	11, 16, 10, 14§	10, 10, 9, 13§
		2011[136]	2–4	27§	23§	8§	12§
		2012[137]	2–4	22§	21§	10§	8§
		2013[138]	2–4	25§	22§	9§	9§
England, GBR	Country	2006/2007[139]	4–5	24.3§	21.5§	10.7§	9.0§
		2007/2008[140]	4–5	24.0§	21.1§	10.4§	8.8§
		2008/2009[141]	4–5	24.0§	21.5§	10.2§	8.9§
		2009/2010[142]	4–5	24.3§	21.8§	10.5§	9.2§
		2010/2011[143]	4–5	23.9§	21.3§	10.1§	8.8§
		2011/2012[144]	4–5	23.5§	21.6§	9.9§	9.0§
		2012/2013[145]	4–5	23.2§	21.2§	9.7§	8.8§
		2013/2014[146]	4–5	23.4§	21.6§	9.9§	9.0§
Georgia	Country	2009[147]	0–4	23.3¶	19.2¶	10.3¶	6.6¶
Ireland	Country	2010/2011[148]	3	23#	25#	5#	6#
		2010/2011[149]	2–4	25‼	21‼	8‼	5‼
Kazakhstan	MICS	2010/2011[117,150]	0–4	16.5	12.8	6.0	3.9
Kosovo	MICS	2013/2014[151]	0–4	4.3¶ (joint)		ND	ND
Kyrgyzstan	DHS	2012[117,152]	0–4	11.1	9.4	4.0	2.1
	MICS	2014[153]	0–4	7.0¶ (joint)		ND	ND
Latvia	Country	2007/2008/2009[154,¡]	5, 6	10.8, 13.4‖	14.0, 19.5‖	2.9, 4.4‖	3.9, 8.0‖
Montenegro	MICS	2013[155]	0–4	24.7¶	19.6¶	ND	ND
Netherlands	Country	2008/2009[156]	2, 3, 4, 5	8.0, 7.8, 9.1, 12.8#	8.3, 12.8, 16,3, 18.1#	0.7, 0.8, 1.1, 2.0#	0.7, 1.6, 2.6, 3.3#
Poland	Country	2010[157]	1–3.0	27.5 (joint)		13.0 (joint)	
Republic of Moldova	MICS	2012[158]	0–4	6.0¶	3.7¶	ND	ND

Supplementary Table 1.1 *(Contd.)*

Country	Survey	Year	Age (*y*)	Overweight (including obesity)† (%)		Obesity‡ (%)	
				Boys	Girls	Boys	Girls
Scotland, GBR	Country	2008[159]	2–6	25.9§	26.0§	7.8§	13.0§
		2009[160]	2–6	23.0§	24.0§	8.9§	11.8§
		2010[161]	2–6	27.5§	24.7§	12.5§	9.3§
		2011[162]	2–6	33.3§	27.9§	15.7§	11.9§
		2012[163]	2–6	32.7§	22.3§	15.0§	9.3§
		2013[164]	2–6	27.3§	25.8§	13.9§	15.3§
Serbia	MICS	2010[117,165]	0–4	16.8	14.6	6.1	6.0
		2014[166]	0–4	15.6¶	12.0¶	ND	ND
Tajikistan	Country	2009[117,167]	0–4	7.1	5.2	1.2	1.0
	DHS	2012[117,168]	0–4	8.8	7.6	3.4	2.7
The former Yugoslav Republic of Macedonia	Country	2010/2011[117,169]	0–4	17.2	17.7	7.9	7.7
	MICS	2011[170]	0–4	13.4¶	11.4¶	ND	ND
Turkey	DHS	2013/2014[117,171]	0–4	11.7¶	9.9¶	ND	ND
Wales, GBR	Country	2011/2012[172,¡]	4–5	29.3§	27.1§	13.0§	12.1§
		2012/2013[173,¡]	4–5	26.8§	25.6§	11.3§	11.4§
		2013/2014[174,¡]	4–5	27.3§	25.6§	12.0§	11.7§
Based on weight and height reported by the children's caregivers							
Belgium	Country	2008[175]	2–4	18.5# (joint)		8.1# (joint)	
		2013[176]	2–4	22.4# (joint)		11.4# (joint)	
Spain	Country	2006/2007[177]	2–3, 4–5	29.4, 29.2#	31.4, 37.0#	14.9, 17.2#	15.7, 19.4#
		2011/2012[178]	2–4	31.1#	28.9#	19.0#	18.6#

Abbreviations: BMI, body mass index; BMI/A, BMI-for-age; DHS, Demographic and Health Survey; GBR, United Kingdom of Great Britain and Northern Ireland; IOTF, International Obesity Task Force; ISO, International Organization for Standardization; MICS, Multiple Indicator Cluster Survey; ND, not determined; WHO, World Health Organization.

Notes. For some countries, the data overlapped the age groups as referred to in Supplementary Tables 1.1 (0–5 years) and 1.2 (6–9 years), in which case the results were presented in the table for which the age range fell closest. Intercountry comparisons should be interpreted with caution due to different data collection methods, age ranges and definitions used for overweight and obesity. GBR is the ISO 3166-1 alpha-3 country code for the United Kingdom of Great Britain and Northern Ireland. "Kosovo" should be read as "Kosovo (in accordance with Security Council resolution 1244 (1999))".

* End year of survey; † Overweight was defined as the proportion of children with a BMI/A value > +2 Z-scores, relative to the 2006 WHO growth standards median[6], unless stated otherwise; ‡ Obesity was defined as the proportion of children with a BMI/A value > +3 Z-scores, relative to the 2006 WHO growth standards median[6], unless stated otherwise; § Overweight and obesity were defined as a BMI/A value ≥ 85th percentile and ≥ 95th percentile, respectively, of the 1990 United Kingdom growth reference data[122,123]; ¶ Overweight was defined as the proportion of children with a weight-for-height value > +2 Z-scores, relative to the 2006 WHO growth standards median[6]; # Overweight and obesity were defined by using cut-off points for BMI, passing through 25 kg/m^2 and 30 kg/m^2 by the age of 18 years, respectively, based on the IOTF recommended growth reference[8,121]; ‖ Overweight and obesity were defined as a BMI/A value > 91st percentile and > 98th percentile, respectively, of the 2006 WHO growth standards data[6]; ¡ School based study; ‖ Overweight and obesity were defined as a BMI/A value > 85th percentile and > 97th percentile, respectively, of the 2007 Latvian growth reference data[124].

Supplementary Table 1.2 Nationally representative prevalence of overweight (including obesity) and obesity in schoolchildren based on country-specific surveys concluded in 2007* or later and represented by population- or school-based data, by country

Country	Year	Age (*y*)	Overweight (including obesity)† (%)		Obesity‡ (%)	
			Boys	Girls	Boys	Girls
Based on measured weight and height						
Austria	2007/2008[179,§]	6–9	20¶ (joint)		8¶ (joint)	
	2010/2011/2012[180,§]	7–9	22.6¶	20.7¶	ND	ND
Bulgaria	2011[181,§]	6–9	38.9	32.4	20.4	15.2
England, GBR	2007[132,#]	6, 7, 8, 9	31, 26, 29, 31‼	31, 30, 25, 31‼	16, 17, 16, 17‼	16, 14, 16, 18‼
	2008[133,#]	6, 7, 8, 9	21, 29, 30, 37‼	24, 25, 28, 36‼	9, 17, 19, 20‼	14, 13, 15, 21‼
	2009[134,#]	6, 7, 8, 9	31, 29, 30, 38‼	22, 24, 33, 30‼	12, 15, 15, 20‼	14, 15, 21, 19‼
	2010[135,#]	6, 7, 8, 9	32, 29, 31, 35‼	27, 35, 27, 30‼	19, 15, 18, 19‼	17, 22, 11, 17‼
	2011[136,#]	5–7, 8–10	23, 33‼	21, 29‼	12, 17‼	11, 24‼
	2012[137,#]	5–7, 8–10	26, 24‼	23, 24‼	12, 11‼	9, 14‼
	2013[138,#]	5–7, 8–10	23, 31‼	25, 28‼	14, 16‼	11, 16‼
France	2006/2007[182,#]	3–10	11.4¦	21.9¦	2.9¦	3.8¦
	2006/2007[183,#]	3–10	11.9¦	16.7¦	2.7¦	3.5¦
	2007[184,§]	7–9	14.1¦	17.7¦	2.8¦	2.8¦
	2012/2013[185,§]	5–6	10.4¦	13.5¦	3.1¦	3.8¦
Greece	2007[186,§]	8–9	38.7¦	37.9¦	12.2¦	11.2¦
Greenland, DNK	2011/2012/2013[187,§]	5–8.0	18.5¦	26.8¦	5.8¦	7.7¦
Ireland	2007/2008[188,§]	9	22¦	30¦	5¦	8¦
Luxembourg	2010/2011[189,§]	5–12	ND	ND	7.9‖	8.4‖
Netherlands	2008/2009[156,#]	6, 7, 8, 9	13.7, 14.3, 14.7, 13.7¦	18.5, 18.8, 18.0, 17.0¦	2.1, 2.1, 2.2, 2.0¦	3.4, 3.4, 3.2, 2.8¦
Poland	2007/2008/2009/2010[190,§]	7–18	18.2¦	14.6¦	4.1¦	3.0¦
Scotland, GBR	2008[159,#]	7–11	43.4‼	23.1‼	22.9‼	11.3‼
	2009[160,#]	7–11	32.6‼	26.4‼	17.6‼	14.3‼
	2010[161,#]	7–11	33.0‼	28.1‼	21.0‼	13.9‼
	2011[162,#]	7–11	36.6‼	27.5‼	28.2‼	16.0‼
	2012[163,#]	7–11	30.5‼	27.0‼	18.4‼	14.2‼
	2013[164,#]	7–11	34.0‼	24.8‼	19.1‼	14.6‼

Supplementary Table 1.2 *(Contd.)*

Country	Year	Age (*y*)	Overweight (including obesity)† (%)		Obesity‡ (%)	
			Boys	Girls	Boys	Girls
Spain	2012[191,#]	8–17	38.6 (joint)		ND	ND
Switzerland	2007[192,§]	6–13	16.8¿	13.3¿	5.3¿	3.3¿
Turkey	2008/2009[193,§]	6–10	22.6	18.9	7.5	5.4
Wales, GBR	2007[194,#]	2–15	35‼	37‼	20‼	19‼
	2008[195,#]	2–15	34‼	31‼	17‼	15‼
	2009[196,#]	2–15	35‼	33‼	20‼	18‼
	2010[197,#]	2–15	38‼	34‼	23‼	16‼
	2011[198,#]	2–15	36‼	34‼	21‼	18‼
	2012[199,#]	2–15	35‼	33‼	20‼	19‼
Based on weight and height reported by the children or by their caregivers						
Belgium	2008[175,#]	5–9	21.8¡ (joint)		8.9¡ (joint)	
	2013[176,#]	5–9	23.3¡ (joint)		8.9¡ (joint)	
Netherlands	2010[200,#]	4–12	12.7¡	14.0¡	2.9¡	3.8¡
	2011[200,#]	4–12	13.2¡	12.2¡	3.1¡	2.8¡
	2012[200,#]	4–12	12.8¡	11.9¡	3.3¡	2.6¡
	2013[200,#]	4–12	11.6¡	12.9¡	2.9¡	2.8¡
Spain	2006/2007[177,#]	6–7, 8–9	34.3, 35.8¡	37.3, 37.6¡	16.4, 12.3¡	18.0, 9.8¡
	2011/2012[178,#]	5–9	34.5¡	39.9¡	13.6¡	16.0¡

Abbreviations: BMI, body mass index; BMI/A, BMI-for-age; DNK, Denmark; GBR, United Kingdom of Great Britain and Northern Ireland; IOTF, International Obesity Task Force; ISO, International Organization for Standardization; ND, not determined; WHO, World Health Organization.

Notes. For some countries, the data overlapped the age groups as referred to in Supplementary Tables 1.1 (0–5 years) and 1.2 (6–9 years), in which case the results were presented in the table for which the age range fell closest. Intercountry comparisons should be interpreted with caution due to different data collection methods, age ranges and definitions used for overweight and obesity. DNK and GBR are ISO 3166-1 alpha-3 country codes for Denmark and the United Kingdom of Great Britain and Northern Ireland, respectively.

* End year of survey; † Overweight was defined as the proportion of children with a BMI/A value > +1 Z-score relative to the 2007 WHO growth reference median[64], unless stated otherwise; ‡ Obesity was defined as the proportion of children with a BMI/A value > +2 Z-scores relative to the 2007 WHO growth reference median[64], unless stated otherwise; § School-based study; ¶ Overweight and obesity were defined as a BMI/A value > 90th percentile and > 97th percentile, respectively, of the German growth reference data[125]; # Population-based study; ‼ Overweight and obesity were defined as a BMI/A value ≥ 85th percentile and ≥ 95th percentile, respectively, of the 1990 United Kingdom growth reference data[122,123]; ¡ Overweight and obesity were defined by using cut-off points for BMI, passing through 25 kg/m² and 30 kg/m² by the age of 18 years, respectively, based on the IOTF recommended growth reference[8,121]; ‖ Definition for obesity was not indicated; ¿ Overweight and obesity were defined as a BMI/A value ≥ 85th percentile and ≥ 95th percentile, respectively, of the 2000 United States of America growth reference data[126].

2

WHO European Childhood Obesity Surveillance Initiative 2008: weight, height and body mass index in 6–9-year-old children

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(With kind permission from the WHO Regional Office for Europe)

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ABSTRACT

Background: Nutritional surveillance in school-age children, using measured weight and height, is not common in the European Region of the World Health Organization (WHO). The WHO Regional Office for Europe has therefore initiated the WHO European Childhood Obesity Surveillance Initiative.

Objective: To present the anthropometric results of data collected in 2007/2008 and to investigate whether there exist differences across countries and between the sexes.

Methods: Weight and height were measured in 6–9-year-old children in 12 countries. Prevalence of overweight, obesity, stunting, thinness and underweight as well as mean Z-scores of anthropometric indices of height, weight and body mass index were calculated.

Results: A total of 168 832 children were included in the analyses and a school participation rate of more than 95% was obtained in eight out of 12 countries. Stunting, underweight and thinness were rarely prevalent. However, 19.3–49.0% of boys and 18.4–42.5% of girls were overweight (including obesity and based on the 2007 WHO growth reference). The prevalence of obesity ranged from 6.0% to 26.6% among boys and from 4.6% to 17.3% among girls. Multi-country comparisons suggest the presence of a north–south gradient with the highest level of overweight found in southern European countries.

Conclusions: Overweight among 6–9-year-old children is a serious public health concern and its variation across the European Region highly depends on the country. Comparable monitoring of child growth is possible across Europe and should be emphasized in national policies and implemented as part of action plans.

INTRODUCTION

Excessive body weight in children and adolescents is a serious public health concern in the European Region of the World Health Organization (WHO)[1] and was addressed at the WHO European Ministerial Conference on Counteracting Obesity[2]. Based on the cut-offs recommended by the International Obesity Task Force (IOTF)[3], it was then estimated that about 20% of the children and adolescents in the WHO European Region were overweight (including obesity) and that a third of them could be classified as obese[1]. A recent review of the data on overweight among preschool children reports prevalence estimates (based on the 2006 WHO Child Growth Standards[4]) of more than 25% in Albania, Bosnia and Herzegovina and Ukraine[5].

While it is generally recognized that nutritional surveillance data are crucial for the development of targeted action and the monitoring of progress and success in counteracting obesity, regular assessments of the magnitude of overweight and obesity, particularly in children and adolescents, are not common in the majority of the 53 WHO European Member States. A comprehensive review conducted for the 2006 Ministerial Conference revealed that by 2006, only 15 Member States had nationally representative objective data for children aged 0–6 years available from 1999 onwards. Based on weight and height measurements, 13 only had national data for the age group 6–10 years and 19 countries monitored overweight and obesity in adolescents (10–19 years)[1]. Little is known about trends in overweight in preschool children, schoolchildren and adolescents in the WHO European Region, and the scarce objective data show variable figures[6–8].

At the first consultation with Member States[9], in the process leading to the 2006 Ministerial Conference, the need was recognized for European-wide and standardized childhood surveillance systems on which policy development within the European Region could be based. As a follow-up to this recommendation, the WHO Regional Office for Europe initiated with 13 Member States (Belgium, Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden) the WHO European Childhood Obesity Surveillance Initiative (COSI). Its aim is to fill the gap in longitudinal information on anthropometry in primary-school children by routinely measuring their body weight and body height. The main reason for choosing this population group was that intercountry-comparable, nationally representative surveys carried out in the European Region mainly target preschool children aged 0–5 years (e.g. through the demographic and health surveys[10] and the multiple indicator cluster surveys[11]) or adolescents aged 11–15 years (e.g. through the Health Behaviour in School-aged Children (HBSC) survey[12] and the Global school–based Student Health Survey (GSHS)[13]).

The first data collection in primary-school children according to the COSI harmonized surveillance methodology took place during the school year 2007/2008. All countries except

Cyprus delivered their 2007/2008 data to the WHO-COSI database and nine countries have already published their national data analyses[14–22]. This paper compares the weight, height, body mass index (BMI) and their derived indices, including estimates of the prevalence of overweight and obesity, of 6–9-year-old schoolchildren from the 12 countries represented in the WHO-COSI database. This age range was chosen because these ages precede puberty and eliminate possible intercountry differences that could be attributed to variations in the onset of signs of puberty[23].

The paper's aim is to investigate whether differences exist in mean values of weight, height and BMI as well as their derived indices and prevalence estimates across the countries and between boys and girls.

METHODS

Protocol development

An agreed common protocol was developed throughout 2007 by participating Member States and the Regional Office and finalized in 2008[24]. The main documents consulted were the protocol of the 2001/2002 HBSC survey[25], the GSHS manual[26], the manuals of the WHO STEPwise approach to Surveillance[27], the surveillance protocol proposed by the European Childhood Obesity Group[23] and the child obesity monitoring guidance of the Department of Health in the United Kingdom[28]. Although each participating country was free to develop a system that fitted its local circumstances, it was important that data were collected according to the COSI protocol. It was also stressed that the COSI system should not replace countries' existing health, anthropometric and dietary surveillance systems that had already been in place or were at the planning stage; on the contrary, the COSI approach should be integrated into the existing systems if possible.

Study population and sampling design

Age groups chosen

Given the differences among countries in school systems, the age of children entering the first class of primary school (reception year), and the number of children repeating a grade, it was difficult to implement a uniform sampling approach that was applicable in every country. Age was therefore taken as the first condition for the sampling procedures. Countries were free to select one or more of the following four COSI age groups: 6.0–6.9, 7.0–7.9, 8.0–8.9 or 9.0–9.9 years. Because children of this age in all countries are enrolled in primary schools, the school population was therefore taken to be representative of the total population in these age groups.

Stratification

Stratification was applied if it was expected that differences in anthropometric measurements and indices across strata would be observed. This was done by seven countries: the Czech Republic by region and level of urbanization; Ireland by health service executive region; Italy by region; Latvia by level of urbanization and language of instruction; Lithuania by district and level of urbanization; Norway by county and administrative health region; and Sweden by type of municipality and type of school (public/private). Countries took account of the expected refusal rates in determining the necessary oversampling.

Sampling units

The entire population of interest was included by Belgium (Flanders only) and Malta (all second grade primary-school classes) and nationally representative samples were taken by the other 10 countries except Portugal (all regions except Madeira) through cluster sampling, whereby the primary sampling unit (PSU) was the primary school or the class (except in the Czech Republic and Norway, as explained below).

Primary schools and classes were selected randomly from the list of all primary schools (public, private and special schools) centrally available in each country through the Ministry of Education or at the national school registry (or national list of primary care paediatricians). If less than about 1% of the target children were enrolled in private or special schools (e.g. schools for mentally handicapped children or children with visual impairment and blindness), countries had the choice of excluding these schools from the sampling frame. If the majority of the children of the targeted age group were in the same grade, then the sample was drawn from within that grade level. If the targeted age group was spread across grades, however, all grades where most children from this age group were present were sampled. In every sampled class, all children were invited to participate. The PSU in the Czech Republic was composed of paediatric clinics, because COSI was attached to the mandatory health checks that are performed by paediatricians. The PSU in Norway was composed of counties, which were selected by simple random sampling and with probability proportional to size.

Sample size

Rudolf *et al*. suggest using the standard deviation (SD) scores or Z-scores of a BMI distribution to demonstrate whether a halt in the rise in overweight or obesity is achieved[29]. The calculated sample size of ≈2300 children per age group was based on an 80% power to detect a minimum difference of 0.10 Z-score in mean BMI per year at a two-sided 5% significance level. To achieve the same precision with a cluster sample design as with a simple random sample, the minimum final effective sample size should be ≈2800 children per age group, whereby a design effect of 1.2 was taken into account[25].

Data collection procedures

The COSI protocol is in accordance with the *international ethical guidelines for biomedical research involving human subjects*[30]. Depending on local circumstances, the procedures were also approved by local ethical committees. Parents were fully informed about all study procedures. Informed consent was obtained using either an active or passive approach, depending on local legal and ethical requirements. In the case of the active approach, their informed consent for the measurements and data treatment was obtained prior to the child's measurement. The child's consent was always obtained prior to the measurements. Confidentiality of all collected and archived data was ensured. The children's names and, in some cases, the entire birth date were not included in the electronic data files sent to the Regional Office.

Countries decided on the measurement period. Data collection, however, was avoided during the first two weeks of a school term or immediately after a major holiday. Taking the local arrangements, circumstances and budget into account, countries chose the most appropriate professionals to collect the data from the children, hereafter called examiners. The following child variables were collected through the examiner's record form: date of birth, sex, postal code or living area, school grade, date of measurement, clothes worn when measured, school code, body weight and body height. A school form was completed either by the school principal, by the teachers of the sampled classes or by someone else who would be able to report on the location of the school, the number of children registered and measured per sampled class, the number registered who had refused to be measured, and the number absent on the day of measurement.

Anthropometric measurements

Prior to data collection, all examiners were trained in measuring weight and height using the outlined WHO standardized techniques[31]. The training also included a review of the background and objectives of the surveillance system, standardized use of the forms, support to children with anxieties, recording measurement values immediately after reading them, and writing legibly to reduce mistakes during data transfer. Measurements were carried out in close collaboration with teachers and other school personnel in a private room in the school (except in the Czech Republic, where measurements were made in paediatric clinics). Children were not routinely informed of their body weight and body height, as this is a surveillance and not a screening programme, which would entail a referral to treatment and follow-up of children who had been identified as being overweight or obese[32].

Children were asked to take off their shoes and socks as well as all heavy clothing (coats, sweaters, jackets, etc.). Furthermore, wallets, mobile phones, key chains, belts or any other objects were removed, as well as hair ornaments or braids. Body weight was measured to the nearest 0.1 kg with portable digital (mainly manufacturer-calibrated) scales (SECA 872, SECA 862, SECA Bella 840, Bellissima 841, Tanita UM-072 or Beurer PS07) and body height

was measured standing upright to the nearest 0.1 cm with a portable stadiometer (SECA 214, TB I Hyssna 4205, SECA 206 or Leicester) according to WHO's measurement protocol[31]. Body weight was then adjusted for the weight of the clothes worn. The average weights of types of clothing (underwear only, gym clothes, light clothing and heavy clothing) were provided by each country. Where possible, the same anthropometric equipment was used throughout a country.

Data elaboration and statistical analysis

All country datasets were reviewed in a standard manner at the Regional Office for inconsistencies and completeness before they were merged for the intercountry analyses. The final dataset included children with informed consent and complete information on age, sex, weight and height. Children were excluded from the final dataset if their age did not fall within the targeted age group.

The child's age was calculated using the formula: (date of measurement minus date of birth)/365.25. When only the month and year of birth were provided, the day of birth was chosen randomly (this was done for 48 Latvian children and the entire Italian dataset). BMI was calculated using the formula: weight (kg) divided by height squared (m^2).

The 2007 WHO recommended cut-offs for school-age children and adolescents were used to compute height-for-age (H/A), weight-for-age (W/A) and BMI-for-age (BMI/A) Z-scores and to interpret anthropometric indicators[33,34], whereby stunting and severe stunting were defined as the proportion of children with a H/A value below –2 Z-scores and below –3 Z-scores, respectively, relative to the 2007 WHO growth reference median. Underweight and severe underweight were defined as the proportion of children with a W/A value below –2 Z-scores and below –3 Z-scores, respectively. Thinness and severe thinness were defined as the proportion of children with a BMI/A value below –2 Z-scores and below –3 Z-scores, respectively. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively. Overweight and obesity were also estimated using the IOTF cut-off points[3], as they are widely used in the WHO European Region (Supplementary Table **2.1**).

According to WHO definitions, the prevalence estimates for stunted children include those who are severely stunted, the prevalence estimates for underweight children include those who are severely underweight, the prevalence estimates for thin children include those who are severely thin, and the prevalence estimates for overweight children include those who are obese[31].

Children with biologically implausible (or extreme) values were excluded from the analysis[34]: W/A values below –6 or above +5 Z-scores; H/A values below –6 or above +6 Z-scores; and BMI/A values below –5 or above +5 Z-scores relative to the 2007 WHO growth reference median.

Sampling weights to adjust for the applied sampling design, oversampling and non-response rate were available for only three countries, and thus the analyses were performed unweighted. Means ± SDs, medians and interquartile ranges were calculated for all measurements (weight, height and BMI) and anthropometric indices (W/A, H/A and BMI/A Z-scores) by age group, sex and country. For each country-specific dataset these six continuous variables were tested by age group for normality using normal quantile–quantile plots. Weight and BMI were found to be highly positively skewed in all datasets. They were therefore transformed to attain normality and their transformed values were used for the intercountry comparisons. Using the command 'ladder' in Stata 10.1 (StataCorp, College Station, TX, USA), the best option suggested was inverse transformation for weight and 1/ square transformation for BMI. Although the distribution of W/A and BMI/A Z-scores was slightly skewed to the right, the command 'ladder' showed no need to apply transformations to normalize them. Prevalence estimates are presented as percentages. The homogeneity of variances was tested using Levene's test[35]. Because the data showed heterogeneity of variances between countries and because of an unbalanced design (unequal group sizes), the main effects of country and sex and their interaction on all mean anthropometric values were assessed using two-way analysis of variance (ANOVA), with the Games–Howell *post hoc* test for the multiple comparisons between countries[36]. This was done separately for three age groups (6-, 7- and 8-year-olds) because not every country had included all age groups. In the case of an interaction effect, a one-way ANOVA was performed to assess significant differences across countries by sex and between sexes by country for all four age groups. Within each age group, the chi-squared test was used to determine differences in the prevalence estimates across countries for the total group and for boys and girls separately. If the chi-squared test was found significant, the Marascuilo procedure was used for the multi-group comparisons of proportions between countries[37]. A chi-squared test was used to assess a linear trend in the prevalence estimates with increasing age for the countries with multiple age groups selected. A P value of < 0.05 was used to determine significance. All statistical analyses, except the Games–Howell *post hoc* tests, were performed in Stata version 10.1. The latter was performed in SPSS version 20.0 (IBM, Armonk, NY, USA).

RESULTS

Sampling, subject and data collection characteristics

A total of 168 832 children aged 6–9 years were included in the data analyses (85 934 boys and 82 898 girls). A school and class participation rate of more than 95% was observed in eight countries. Table **2.1** summarizes the sampling characteristics for each of the 12 participating countries. Table **2.2** shows the number of children who were invited to participate, who were

measured, who had complete information on age, sex, weight and height, and who fell within the targeted age group. Table 2.3 gives an overview of the application of the COSI protocol characteristics in each country.

Table 2.1 Sampling characteristics for each of the 12 countries that participated in COSI Round 1 (2007/2008)

Characteristics	Countries											
	BEL	BGR	CZE	IRL	ITA	LVA	LTU	MLT	NOR	PRT	SVN	SWE
Sampling design												
Inclusion of entire targeted age group	✓							✓*				
Cluster sampling design		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Schools (PSU)												
Total approached (*n*)	NA	184	60†	498	NA	193	161	97	131‡	189	118	220
Total included (*n*)	NA	184	46†	163	NA	190	155	95	127‡,§	181	118	94
Participation rate (%)	NA	100	76.7	32.7	NA	98.4	96.3	97.9	96.9	95.8	100	42.7
Classes (SSU)												
Total approached (*n*)	NA	190	NA	163	459¶	300	309	192	131#	362	774	306
Total included (*n*)	NA	190	NA	163	456¶	300	309	192	127#	362	774	306
Participation rate (%)	NA	100	NA	100	99.3	100	100	100	96.9	100	100	100

Abbreviations: ✓, applicable; BEL, Belgium (Flanders); BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NA, not applicable; NOR, Norway; PRT, Portugal (all regions except Madeira); PSU, primary sampling unit; SSU, secondary sampling unit; SVN, Slovenia; SWE, Sweden.
Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.
* All second grade classes of 95 primary schools in Malta were included; † Paediatric clinics formed the PSU and number of paediatric clinics, instead of number of schools, is given; ‡ Counties formed the PSU; § Four selected schools were excluded because they had only one pupil from the targeted age group; ¶ Classes formed the PSU; # Schools formed the SSU.

Weight, height, body mass index, weight-for-age, height-for-age and body mass index-for-age Z-scores

Median values for weight and mean values for W/A Z-score are presented in Table 2.4, mean values for height and H/A Z-score in Table 2.5, and median values for BMI and mean values for BMI/A Z-score in Table 2.6. All mean Z-score values except one were found to be positive. Weight (Table 2.4) and height (Table 2.5) increased with age and boys were taller and heavier than girls in all age groups.

Table 2.2 Number of children targeted, measured and included in the final dataset for each of the 12 countries that participated in COSI Round 1 (2007/2008)

	Countries											
	BEL	**BGR**	**CZE**	**IRL**	**ITA**	**LVA**	**LTU**	**MLT**	**NOR**	**PRT**	**SVN**	**SWE**
Total number of children sampled, and												
Invited to participate (*n*)	–	4308	1708	3637	8850	5689	5877	3734	3952	4458	13 670	5326
Measured (%)	–	78.7	99.2	72.3	90.4	78.9	84.2	91.3	87.9	81.6	87.4	88.4
With complete information (%)	–	78.5	99.1	72.3	90.4	78.9	84.0	91.3	87.9	81.6	87.4	84.9
Fell within the targeted age group(s) (%)	–	57.8	53.6	66.2	90.4	57.1	56.3	57.1	71.7	40.7	87.4	68.9
Total number of targeted children included for this paper's analyses												
6-year-olds; boys/girls (*n*)	25 071/ 24 465	0	0	0	0	0	0	1092/ 1041	0	0	1620/ 1654	0
7-year-olds; boys/girls (*n*)	7384/ 6419	1258/ 1230	445/ 470	1143/ 1266	0	1651/ 1598	1660/ 1649	0	0	911/ 904	2374/ 2319	763/ 709
8-year-olds; boys/girls (*n*)	22 681/ 22 256	0	0	0	2629/ 2515	0	0	0	1435/ 1399	0	2028/ 1945	1131/ 1062
9-year-olds; boys/girls (*n*)	9186/ 8616	0	0	0	1472/ 1381	0	0	0	0	0	0	0

Abbreviations: –, this information was not collected by age, thus was unknown for the age group 6–9-year-olds; BEL, Belgium (Flanders); BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia; SWE, Sweden.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

Table 2.3 Implementation of the WHO European Childhood Obesity Surveillance Initiative's protocol characteristics by each of the 12 countries that participated in COSI Round 1 (2007/2008)

COSI protocol characteristics	Countries											
	BEL	BGR	CZE	IRL	ITA	LVA	LTU	MLT	NOR	PRT	SVN	SWE
COSI surveillance system												
Integration with routine measurements	✓		✓					✓			✓	
Newly established surveillance system		✓		✓	✓	✓	✓		✓	✓		✓
Data collection period												
Starting (*month/year*)	09/07	03/08	01/08	04/08	04/08	02/08	04/08	04/08	09/08	05/08	04/08	03/08
Ending (*month/year*)	07/08	05/08	12/08	06/08	06/08	03/08	05/08	06/08	11/08	06/08	04/08	06/08
Informed parental consent approach												
Passive	NA*	✓			✓	✓						✓
Active	NA*		✓	✓			✓	✓	✓	✓	✓	
Field examiners												
External health professionals linked to the school			✓		✓			✓	✓			
Physical education teachers											✓	
Nationally or regionally based examiners	✓	✓		✓		✓	✓			✓		✓

Abbreviations: ✓, applicable; BEL, Belgium (Flanders); BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NA, not applicable; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia; SWE, Sweden; WHO, World Health Organization.
Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.
* In Flanders (Belgium), measurements of body weight and body height in schoolchildren are part of the preventive medical examinations, which are carried out within the school system and are mandatory by law.

Table 2.4 Median and interquartile range (Q1–Q3) values of weight and mean (SD) values of weight-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 1 (2007/2008), by age and country†

Age group and country	Weight‡ (*kg*)		W/A Z-score	
	Boys	Girls	Boys	Girls
	Median (Q1–Q3)		Mean (SD)	
6-year-olds	§	§	§	§
BEL	22.7 (20.7–24.9)[¶,a]	22.2 (20.2–24.7)[a]	0.37 (1.06)[¶,a]	0.34 (1.00)[a]
MLT	23.4 (21.1–26.3)[¶,b]	22.5 (20.2–25.9)[b]	0.52 (1.32)[¶,b]	0.38 (1.21)[a]
SVN	24.0 (21.9–27.1)[¶,c]	23.8 (21.3–26.6)[c]	0.76 (1.18)[¶,c]	0.66 (1.10)[b]
7-year-olds	§	§	§	§
BEL	25.1 (22.7–28.3)[a]	25.0 (22.3–28.6)[a]	0.38 (1.18)[a]	0.42 (1.11)[a]
BGR	25.2 (22.5–29.3)[a,b]	25.1 (22.1–29.4)[a,b]	0.39 (1.36)[a]	0.40 (1.32)[a,b]
CZE	24.9 (22.5–28.0)[¶,a]	24.0 (21.9–27.2)[c]	0.57 (1.22)[¶,a,b]	0.42 (1.00)[a,c]
IRL	25.9 (23.6–29.2)[¶,b,c]	25.6 (23.0–28.6)[b,d]	0.57 (1.18)[b]	0.54 (1.02)[b,c,d,e]
LVA	26.4 (23.8–29.4)[¶,c,d]	25.5 (23.0–28.7)[b,e]	0.61 (1.12)[¶,b]	0.45 (1.03)[a,d,f]
LTU	26.6 (24.3–29.7)[¶,d,e]	25.9 (23.5–29.4)[d,f]	0.66 (1.14)[¶,b]	0.56 (1.06)[c,f,g]
PRT	26.4 (23.5–30.1)[c,d]	25.8 (22.8–29.6)[d,e,g]	0.70 (1.28)[b]	0.64 (1.17)[e,g,h]
SVN	26.9 (24.1–31.0)[¶,e]	26.1 (23.5–30.0)[f,g,h]	0.87 (1.25)[¶,c]	0.70 (1.11)[h]
SWE	26.5 (24.4–29.6)[¶,d,e]	26.1 (23.5–29.3)[d,e,h]	0.63 (1.04)[b]	0.53 (0.98)[a,d,g]
8-year-olds	§	§	§	§
BEL	28.4 (25.7–31.9)[¶,a]	28.1 (25.2–32.1)[a]	0.46 (1.10)[¶,a]	0.40 (1.05)[a]
ITA	31.3 (27.3–37.2)[¶,b]	30.4 (26.2–35.5)[b]	1.00 (1.33)[¶,b]	0.71 (1.22)[b]
NOR	28.7 (26.1–32.0)[¶,a]	28.3 (25.3–32.0)[a,c]	0.59 (1.07)[¶,c]	0.48 (1.01)[c]
SVN	30.0 (26.8–34.9)[¶,c]	29.8 (26.1–34.1)[d]	0.89 (1.26)[¶,d]	0.73 (1.12)[b]
SWE	29.5 (26.4–33.4)[¶,d]	28.7 (25.8–32.7)[c]	0.67 (1.12)[¶,c]	0.52 (1.04)[c]
9-year-olds	§		§	§
BEL	31.6 (28.2–36.3)	31.7 (27.9–37.1)	0.47 (1.16)[¶]	0.37 (1.16)
ITA	32.6 (28.5–39.0)[¶]	31.7 (27.5–37.7)	0.88 (1.29)[¶]	0.58 (1.26)

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal (all regions except Madeira); Q1, first quartile; Q3, third quartile; SD, standard deviation; SVN, Slovenia; SWE, Sweden; W/A, weight-for-age; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d,e,f,g,h] Within each sex-age group (e.g. 6-year-old boys), mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 6-year-old boys, each mean W/A Z-score value is significantly different from the other two whereas the value of Slovenian 6-year-old girls differed significantly from the other two and no significant difference was found between Belgian and Maltese 6-year-old girls; * Based on the 2007 WHO growth reference for school-age children and adolescents[33]; † Body weight was adjusted for clothes worn when measured and children with a W/A Z-score < –6 or > +5 were excluded; ‡ Non-normally distributed and underwent inverse transformation prior to ANOVA and Games–Howell *post hoc* tests; § Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA); ¶ Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA).

Table 2.5 Mean (SD) values of height and height-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 1 (2007/2008), by age and country†

Age group and country	Height (*cm*)		H/A Z-score	
	Boys	Girls	Boys	Girls
	Mean (SD)			
6-year-olds	‡	‡	‡	‡
BEL	120.7 (5.2)[§,a]	119.8 (5.3)[a]	0.35 (0.98)[a]	0.34 (0.96)[a]
MLT	120.3 (5.3)[§,a]	118.9 (5.7)[b]	0.07 (1.01)[§,b]	–0.03 (1.06)[b]
SVN	124.0 (5.4)[§,b]	123.0 (5.4)[c]	0.83 (1.02)[c]	0.78 (1.00)[c]
7-year-olds	‡	‡	‡	‡
BEL	125.9 (6.0)[§,a]	125.3 (6.2)[a]	0.29 (1.03)[a]	0.29 (1.02)[a]
BGR	126.5 (6.8)[§,a]	125.7 (6.5)[a]	0.24 (1.20)[a]	0.24 (1.12)[a]
CZE	126.2 (5.8)[§,a]	125.0 (5.2)[a]	0.67 (1.05)[b,c]	0.57 (0.91)[b]
IRL	125.9 (5.7)[§,a]	125.4 (5.5)[a]	0.23 (1.05)[a]	0.30 (0.98)[a]
LVA	128.5 (5.8)[§,b]	127.4 (5.7)[b]	0.59 (1.03)[b]	0.57 (0.99)[b]
LTU	129.2 (5.6)[§,c]	128.6 (5.5)[c]	0.69 (1.01)[b]	0.72 (0.95)[c]
PRT	125.8 (6.0)[§,a]	125.1 (6.2)[a]	0.24 (1.06)[a]	0.27 (1.09)[a]
SVN	129.0 (5.8)[§,b,c]	128.1 (5.7)[c]	0.81 (1.00)[c]	0.77 (0.95)[c]
SWE	129.2 (5.5)[§,c]	128.0 (5.7)[b,c]	0.67 (0.97)[b]	0.58 (0.98)[b]
8-year-olds	‡	‡	‡	‡
BEL	132.8 (5.9)[§,a]	131.9 (6.0)[a]	0.48 (0.99)[§,a]	0.40 (0.97)[a]
ITA	133.0 (6.0)[§,a]	131.7 (6.0)[a]	0.39 (1.01)[§,b]	0.25 (0.99)[b]
NOR	133.2 (5.9)[§,a]	131.7 (5.7)[a]	0.65 (0.99)[§,c]	0.47 (0.94)[c]
SVN	134.1 (6.0)[§,b]	133.4 (5.8)[b]	0.77 (1.00)[d]	0.71 (0.96)[d]
SWE	134.1 (6.0)[§,b]	132.8 (6.2)[b]	0.70 (1.01)[§,c,d]	0.55 (1.00)[c]
9-year-olds	‡	‡	‡	‡
BEL	137.7 (6.6)[§]	137.3 (6.8)	0.40 (1.01)[§]	0.24 (1.03)
ITA	135.5 (6.2)[§]	134.5 (6.2)	0.30 (1.02)[§]	0.12 (1.02)

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; H/A, height-for-age; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal (all regions except Madeira); SD, standard deviation; SVN, Slovenia; SWE, Sweden; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d] Within each sex-age group (e.g. 7-year-old girls), mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 7-year-old girls, the mean height of Belgian, Bulgarian, Czech, Irish and Portuguese girls does not differ from each other. Also, no significant difference was found between Latvian and Swedish girls or among Lithuanian, Slovenian and Swedish girls; however, they differ significantly from each other with the use of another superscript; * Based on the 2007 WHO growth reference for school-age children and adolescents[33]; † Children with a H/A Z-score < –6 or > +6 were excluded; ‡ Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA); § Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA).

Table 2.6 Median and interquartile range (Q1–Q3) values of BMI and mean (SD) values of BMI-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 1 (2007/2008), by age and country†

Age group and country	BMI‡ (*kg/m²*)		BMI/A Z-score	
	Boys	Girls	Boys	Girls
	Median (Q1–Q3)		Mean (SD)	
6-year-olds	§	§	§	§
BEL	15.5 (14.7–16.5)¶,a	15.5 (14.6–16.6)a	0.20 (1.09)a	0.18 (1.01)a
MLT	16.2 (15.1–17.6)b	16.0 (15.0–17.5)b	0.66 (1.34)¶,b	0.54 (1.19)b
SVN	15.7 (14.7–17.2)c	15.7 (14.6–17.1)c	0.35 (1.33)c	0.29 (1.21)c
7-year-olds	§	§	§	§
BEL	15.8 (14.9–17.1)¶,a	15.9 (14.8–17.4)a	0.28 (1.21)¶,a	0.32 (1.11)a
BGR	15.8 (14.8–17.6)a,b	16.0 (14.6–18.0)a,b	0.31 (1.41)a	0.34 (1.33)a,b
CZE	15.7 (14.8–16.9)a	15.4 (14.4–16.9)c	0.22 (1.31)a	0.09 (1.09)c
IRL	16.3 (15.4–17.8)c,d	16.2 (15.3–17.7)d	0.61 (1.18)¶,b,c	0.50 (1.00)d
LVA	16.0 (15.1–17.2)¶,b	15.7 (14.7–17.0)c,e	0.35 (1.16)¶,a	0.16 (1.02)c
LTU	16.0 (15.0–17.3)¶,b	15.8 (14.7–17.2)b,c,e	0.36 (1.20)¶,a	0.20 (1.12)b,c
PRT	16.6 (15.4–18.4)c	16.5 (15.3–18.4)f	0.77 (1.28)¶,b	0.66 (1.14)e
SVN	16.2 (15.1–18.1)¶,d	16.0 (14.8–17.7)a	0.54 (1.38)¶,c	0.35 (1.19)a
SWE	16.0 (15.1–17.2)a,b	16.0 (14.9–17.4)a,e	0.31 (1.08)a	0.26 (0.99)a,c
8-year-olds	§	§	§	§
BEL	16.0 (15.1–17.4)¶,a	16.1 (15.0–17.8)a	0.22 (1.16)a	0.23 (1.07)a
ITA	17.6 (16.0–20.4)¶,b	17.5 (15.7–19.9)b	1.05 (1.39)¶,b	0.75 (1.24)b
NOR	16.2 (15.2–17.5)a,c	16.3 (15.1–17.8)a	0.29 (1.14)a,c	0.28 (1.05)a
SVN	16.8 (15.5–18.7)¶,d	16.6 (15.2–18.7)c	0.63 (1.35)¶,d	0.46 (1.18)c
SWE	16.3 (15.3–17.8)c	16.3 (15.1–17.9)a	0.35 (1.18)c	0.29 (1.04)a
9-year-olds	§	§	§	§
BEL	16.6 (15.4–18.5)¶	16.8 (15.4–19.0)	0.32 (1.26)	0.29 (1.17)
ITA	17.8 (16.0–20.8)¶	17.5 (15.7–20.3)	0.96 (1.35)¶	0.65 (1.28)

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal (all regions except Madeira); Q1, first quartile; Q3, third quartile; SD, standard deviation; SVN, Slovenia; SWE, Sweden; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

a,b,c,d,e,f Within each sex-age group (e.g. 8-year-old boys), mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 8-year-old boys, the mean BMI/A Z-scores of both Italian and Slovenian boys significantly differ from the other four, whereas the values of Belgian and Norwegian boys do not differ from each other as well as the values of Norwegian and Swedish boys; * Based on the 2007 WHO growth reference for school-age children and adolescents[33]; † Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded; ‡ Non-normally distributed and underwent 1/square transformation prior to ANOVA and Games–Howell *post hoc* tests; § Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA); ¶ Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA).

In general, two groups of countries with relatively similar mean BMI/A Z-score values (sexes combined) could be identified: a group with mean BMI/A Z-score values below 0.35 ('low') whereby values for most countries did not statistically differ from each other (Belgium, Bulgaria, Czech Republic, Latvia, Lithuania, Norway and Sweden) and a group with mean values above 0.45 ('high') (Ireland, Italy, Malta, Portugal and Slovenia) (Table **2.6**). High values were found in two out of three Slovenian age groups, and thus Slovenia was included in the group with high mean BMI/A Z-scores.

Two-way ANOVA showed a statistically significant interaction effect of country and sex on most mean anthropometric values (W/A Z-score and BMI/A Z-score ($P < 0.0001$) for each of the three age groups; height and H/A Z-score for the 8-year-old group ($P < 0.05$); inverse-transformed weight and 1/square-transformed BMI for both the 7- and the 8-year-old groups ($P < 0.0001$)). Hence, one-way ANOVA analyses were performed to assess within each age group the country effect for boys and girls separately and the sex effect for each country separately. The main effect of country ($P < 0.001$) on all mean values (except for one) and the main effect of sex ($P < 0.05$) on most mean values were statistically significant. Results from the one-way ANOVA analyses are also presented in Tables **2.4–2.6**. Subsequently, Games–Howell *post hoc* tests were performed for boys and girls separately within each age group to study the differences between countries in more detail (see Tables **2.4–2.6**).

Prevalence of stunting, underweight and thinness

Stunting, underweight and thinness were rarely prevalent in all countries. All values for severe stunting, stunting, severe underweight, underweight and severe thinness were below 2.5%. Values for thinness greater than 2.5%, but still close to what is expected in a normally distributed population, were found in Bulgarian and Czech 7-year-old boys (both 3.2%).

Prevalence of overweight and obesity

Table **2.7** presents the proportions of overweight and obese boys and girls in each age group and country, based on both the WHO and IOTF definitions. Based on WHO definitions, comparing the countries with low mean BMI/A Z-scores, the prevalence of overweight (including obesity) varied from 19.3% to 28.2% in boys and from 18.4% to 27.7% in girls, whereas the prevalence of obesity varied from 6.0% to 12.6% in boys and from 4.6% to 12.0% in girls. In those countries with high BMI/A Z-scores, the prevalence of overweight varied from 28.0% to 49.0% in boys and from 23.6% to 42.5% in girls, and the prevalence of obesity varied from 11.6% to 26.6% in boys and from 7.7% to 17.3% in girls. Based on IOTF definitions, the COSI results revealed a range in overweight (including obesity) prevalence in the countries with low mean BMI/A Z-score values from 11.2% to 20.1% in boys and from 14.7% to 24.2% in girls, while the prevalence of obesity varied from 2.1% to 6.6% in boys and from 3.1% to 9.0% in girls. In the countries with high mean BMI/A Z-score values, the

Table 2.7 Prevalence of overweight (including obesity) and obesity in boys and girls aged 6–9 years in COSI Round 1 (2007/2008), by age and country

Age group and country	Prevalence of overweight (including obesity)* (%)				Prevalence of obesity* (%)			
	WHO definition†		IOTF definition‡		WHO definition†		IOTF definition‡	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6-year-olds								
BEL	19.3[a]	18.4[a]	11.2[a]	14.9[a]	6.0[a]	5.1[a]	2.9[a]	3.8[a]
MLT	34.3[b]	29.3[b]	22.7[b]	24.8[b]	14.7[b]	11.7[b]	9.0[b]	10.6[b]
SVN	28.0[c]	23.6[c]	19.2[b]	19.3[c]	11.7[b]	8.4[c]	6.0[c]	6.7[c]
7-year-olds								
BEL	23.4[a]	24.3[a,b]	15.2[a]	19.4[a,b]	9.1[a,b]	8.0[a,b]	4.4[a]	5.9[a,b,c,e]
BGR	28.2[a,b]	27.7[a,c]	20.1[b,c]	24.2[a,c]	12.6[a,c]	12.0[c]	6.6[a,b]	9.0[b]
CZE	21.4[a]	20.2[a,b,d]	15.8[a,b]	14.7[b,d]	9.7[a,b,c]	5.7[a,b,d]	3.8[a,b,c]	4.0[a,c,d]
IRL	31.8[b]	27.3[a,b]	21.1[b,c]	22.8[a,b,c]	11.6[a,b,c]	7.7[a,b,c,d]	6.3[a,b]	5.6[a,b,c,d,e]
LVA	24.0[a]	18.9[d]	15.3[a,b]	15.1[d]	8.6[a,b]	4.6[d]	4.5[a,c]	3.1[d]
LTU	24.8[a]	21.0[b,d]	16.1[a,b]	16.2[b,d]	9.4[a,b]	7.2[a,b,d]	5.1[a,b]	5.1[a,c,d,e]
PRT	40.5[c]	35.5[c]	26.8[c]	28.5[c]	16.7[c]	12.6[c]	7.9[a,b]	9.3[b,e]
SVN	32.5[b]	28.0[a]	24.2[c]	22.0[a,c]	15.6[c]	9.8[a,c]	7.6[b]	6.7[a,b]
SWE	23.5[a]	22.0[a,d]	14.6[a,b]	17.8[a,b,d]	6.8[b]	5.1[b,d]	2.1[c]	3.2[c,d]
8-year-olds								
BEL	22.1[a]	22.7[a]	13.9[a]	17.4[a]	8.1[a]	6.3[a]	3.4[a]	3.9[a]
ITA	49.0[b]	42.5[b]	37.2[b]	34.7[b]	26.6[b]	17.3[b]	13.6[b]	11.8[b]
NOR	23.0[a,c]	23.1[a]	13.5[a,c]	17.4[a]	7.5[a]	6.0[a]	3.0[a]	4.0[a]
SVN	35.9[d]	31.7[c]	25.2[d]	25.6[c]	16.4[c]	10.9[c]	8.0[c]	6.8[c]
SWE	26.3[c]	23.5[a]	17.4[c]	17.9[a]	9.7[a]	6.8[a]	2.9[a]	3.8[a]
9-year-olds								
BEL	27.4	27.1	18.0	21.9	10.9	8.9	4.8	5.4
ITA	47.1	40.1	35.5	33.6	25.7	15.8	12.6	10.3

Abbreviations: BEL, Belgium (Flanders); BMI/A, body mass index-for-age; BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IOTF, International Obesity Task Force; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia; SWE, Sweden; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d,e] Within each sex-age group (e.g. 6-year-old girls), proportions that share the same superscript letter do not statistically significantly differ from each other (Marascuilo procedure). For example, for the 6-year-old girls, each prevalence estimate is significantly different from the other two. The prevalence of overweight based on IOTF definition and the prevalence of obesity based on WHO definition of Maltese and Slovenian 6-year-old boys do not differ significantly from each other but they differ significantly from the estimate found in Belgium; * Body weight was adjusted for clothes worn when measured; † Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[33]. Children with a BMI/A Z-score < –5 or > +5 were excluded; ‡ Prevalence estimates were based on the IOTF recommended growth reference for school-age children and adolescents[3]. Children with a BMI/A Z-score < –5 or > +5 were excluded (based on the 2007 WHO growth reference[33]).

prevalence of overweight varied from 19.2% to 37.2% in boys and from 19.3% to 34.7% in girls, and the prevalence of obesity varied from 6.0% to 13.6% in boys and from 5.6% to 11.8% in girls.

The chi-squared test comparing the prevalence estimates across countries was significant for all age groups ($P < 0.001$ for boys and girls separately). The Marascuilo procedure was then used to study country differences for each age group (see Table **2.7**; countries within each sex-age group that share the same superscript do not statistically differ from each other).

Based on WHO definitions, the observed linear trend in the prevalence of both overweight and obesity with increasing age was significant for boys and girls separately for Belgium ($P < 0.001$) and for Slovenia ($P < 0.05$). For Sweden, the increasing obesity trend with increasing age was significant only in boys ($P = 0.026$). The observed decreasing trend in Italy with increasing age was not significant for both boys and girls. Similar results were found when comparing the prevalence estimates based on IOTF definitions, except no significant increasing obesity trend was found in Slovenia and no significant increasing overweight and obesity trends with increasing age in Sweden.

Figure **2.1** illustrates the geographical distribution of the prevalence of overweight and obesity in 12 countries, grouped by subregions, of the WHO European Region (sexes combined and based on WHO definitions).

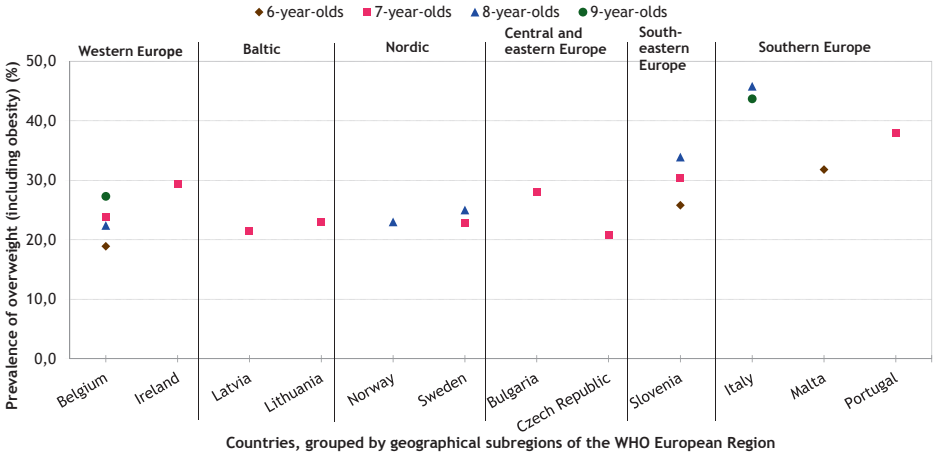
DISCUSSION

Stunting, underweight and thinness were rarely prevalent in all countries under study. With just a single exception all mean Z-score values were positive, meaning that the entire distribution has shifted to the right compared to the reference distribution. The prevalence of overweight (including obesity and based on WHO definitions[33]) varied from 19.3% to 49.0% in boys and from 18.4% to 42.5% in girls, and the prevalence of overweight (including obesity and based on IOTF definitions[3]) varied from 11.2% to 37.2% in boys and from 14.7% to 34.7% in girls.

The overweight and obesity prevalence estimates based on WHO definitions were in all cases higher than those based on IOTF definitions. Based on WHO definitions, boys were more overweight than girls in all age groups except Belgian 7- and 8-year-olds and Norwegian 8-year-olds; boys were more obese than girls in all age groups. Based on IOTF definitions, an opposite pattern was observed whereby girls were more overweight or obese than boys in most cases.

A possible explanation for this difference is that the WHO cut-off values (for both overweight and obesity) for boys are lower than the values for girls at all age points from 6 to 9 years. On the contrary, the IOTF overweight cut-off values for boys are higher than the values for girls up to '9 years:6 months' and the IOTF obesity cut-off values for boys are

(a)



(b)

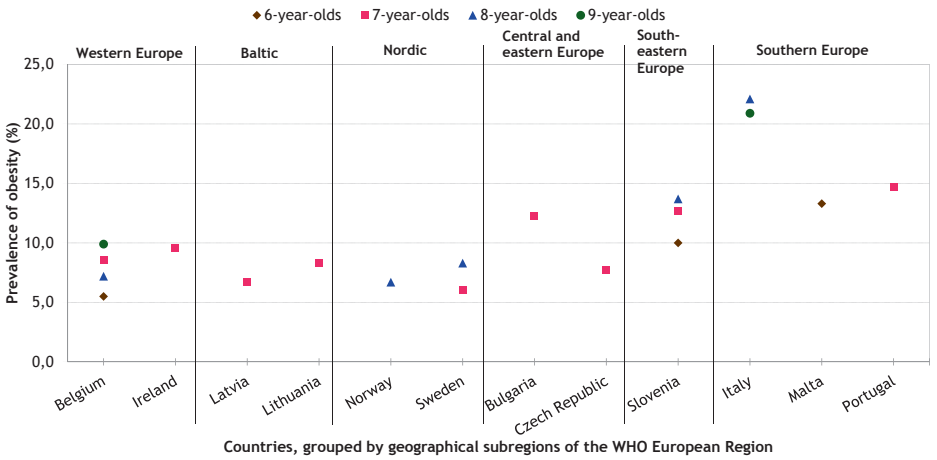


Figure 2.1 Geographical distribution of the prevalence of overweight (including obesity) (a) and obesity (b) in children aged 6–9 years (sexes combined) of COSI Round 1 (2007/2008), based on WHO definitions*

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; WHO, World Health Organization.

* Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[33]. Children with a body mass index-for-age Z-score < –5 or > +5 were excluded. Belgium represents Flanders only and Portugal represents all regions except Madeira. WHO European Member States are grouped into eight geographic subregions to facilitate comparative analysis and interpretation. None of the central Asian republics or the Commonwealth of Independent States participated in the first round, and thus these two subregions are excluded from both figures.

higher than the values for girls from the age '6 years:0 months' up to '8 years:3 months', at which stage they become similar or lower with increasing age (Supplementary Table **2.1**). Furthermore, the WHO BMI/A growth reference was constructed up to the age of 19 years, which is the WHO upper age limit of adolescence[38]. The IOTF growth reference extends to the age of 18 years, and hence the cut-offs for overweight and obesity are higher than those of WHO at similar ages, resulting in lower prevalence estimates[3].

The European Childhood Obesity Group has recently recommended the use of both IOTF and WHO definitions in prevalence studies so that comparisons between epidemiological studies can be made[39]. The observed differences between WHO and IOTF prevalence estimates may, however, have consequences for national policy-making. Depending on the definitions used, resulting in different estimates and magnitudes, policy-makers may opt for targeted policy actions or for no further action because overweight is considered or not considered a public health problem, respectively. Moreover, recent research has demonstrated that the WHO defined cut-offs for overweight are associated with a range of cardiometabolic risk factors in children and adolescents, including carotid artery stiffness as an early marker of vascular lesions[40,41]. The study by Kakinami *et al*. showed that the ability of BMI to predict cardiometabolic risk varied according to the specific cardiometabolic risk factor of interest, as well as to age and sex[40]. In their study, the suggested optimal BMI percentile cut-offs for detecting cardiometabolic risk were lower than the WHO-defined cut-offs for overweight and obesity, thus much lower than the IOTF-defined cut-offs.

Two European studies could be identified which reported on the physical status of schoolchildren, based on the 2007 WHO growth reference[33]. A nationally representative school-based study[42] conducted in Poland between November 2007 and March 2009 among children aged 6–18 years also found a lack of prevalence of stunting (< 2.5%) similar to COSI results. The second study identified was carried out in 2006 in one district of the Russian Federation[43] among adolescents aged 14–17 years. The overall prevalence of stunting and thinness was 3.3% and 3.6%, respectively, and the prevalence of overweight (including obesity) (boys 12.4%; girls 8.9%) and obesity (boys 6.1%; girls 3.7%) was lower than the COSI prevalence estimates, whereby boys were more overweight or obese than girls.

In comparing the COSI results with other nationally representative studies that had been carried out around the same period, had measured the children's weight and height, and had used the IOTF definitions, surprisingly only three studies (all conducted in France) could be identified[44–46]. The first, conducted in 2007 in 7–9-year-old children, found a prevalence of overweight (including obesity) of 14.1% in boys and 17.7% in girls[44]. The national study on individual food consumption (2006/2007) reported a prevalence of overweight (including obesity) of 11.9% and 16.7% in 3–10-year-old boys and girls, respectively[45], and the national nutrition and health survey (2006/2007) reported a prevalence of overweight (including obesity) of 11.4% and 21.9% in 3–10-year-old boys and girls, respectively[46]. These prevalence estimates are within the range of COSI countries with low mean BMI/A Z-score values.

Regardless of WHO or IOTF definitions, the multiple comparisons of proportions suggested that southern European countries – Italy, Malta, Portugal and Slovenia – differed significantly from almost all other participating countries. These results suggest the presence of a north–south gradient with the highest overweight prevalence values found in southern European countries. This has also been presented in other European-wide reviews on children[6], adolescents[7] and adults[47]. Regardless of magnitude, variation was also found within COSI countries based on geographical areas[17,19,21,22]. For instance, in Italy, some types of behaviour known to be associated with obesity[17] and maternal perception[48] also showed geographical differences.

Body weight and BMI were found to be highly positively skewed in all country datasets. A positively skewed BMI distribution has also been reported elsewhere[49–51], whereas to our knowledge a skewed weight distribution in European schoolchildren below 10 years of age has not been addressed except in a recent Polish study[42]. Similar results have been noted outside Europe, e.g. in children aged 6–10 years in the United States of America[52] and children aged 7–12 years in Australia[53].

The combination of nationally representative samples and standardized weight and height measurements in about 168 000 children in a large number of countries has not previously been done. Other identified European-wide studies included local or regional samples or used self-reported data, e.g. the European-wide study 'Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA)'[54], the 'Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS)' (18 626 children 4–11 years old)[55], the HBSC survey (11, 13 and 15-year-olds)[12] or the Pro Children Study (8317 11-year-olds)[56]. The only European study that could be identified as a study using both national samples and measured data was the 'EuropeaN Energy balance Research to prevent excessive weight Gain among Youth (ENERGY)' project, which targets adolescents aged 10–12 years in seven countries[57]. This shows that COSI provides a unique standardized large dataset compared with the currently available European-wide studies.

COSI aimed to set up a surveillance system to be used for policy actions (rather than for research purposes) and each country was responsible for its national data collection to be funded from local resources. Although it was recognized that data comparability would have been improved if identical equipment were used, this was not mandatory, largely because of cost implications. The monitoring of data quality procedures was stressed throughout the measurement period.

For the 10 countries that took a representative sample of children, the PSU was the primary school or the class (except in the Czech Republic and Norway). Some differences in sample selection as well as in period and duration of data collection might have influenced the results. Six countries did not obtain a final sample of children that contained more than 60% of the approached children and fell within the targeted age group, while six countries

did not achieve the minimum final effective sample size of ≈2800 children per age group. The sample size calculation was based on a minimum difference of 0.10 BMI/A Z-score per year and will become essential for the comparison with the results of the next data collection rounds. Another limitation was the observed low school participation rates in Ireland (32.7%) and Sweden (42.7%), although the participating schools were found to be representative of all primary schools in Ireland[15] and Sweden[22].

While 10 countries started data collection during the first semester of 2008, Norway started in September 2008 due to their joining the COSI at a later stage than the other countries, and measurements in Belgium (Flanders) already started in September 2007 because they were carried out as part of the mandatory preventive medical examinations that are done throughout the entire school year. Although 10 countries managed to collect the data over the short time span of 1–3 months, measurements were not done during the same period. Seasonal variation may have influenced weight and prevalence of obesity, as has been observed in other studies[58,59].

The representativeness of a sample of the population of interest is an important source of uncertainty in prevalence studies. The children were selected from the school population in most countries, as this was presumed to be representative of the total population for the 6-, 7-, 8- and 9-year-olds. The analyses performed, however, were unweighted (which is another limitation), because sampling weights to adjust for the applied sampling design, oversampling and non-response rate were available for only three countries. Confidence intervals were therefore not presented for each of the prevalence estimates because they would reflect more the consequence of the sample size obtained. Presenting them would thus have misled the interpretation of the results.

CONCLUSION AND WAY FORWARD

COSI covers the primary school age to fill the current gap in information on the physical status of this population group. High overweight prevalence values were found during the first data collection round and its variation across the European Region significantly depends on the country. As only 13 countries participated in this round (of which 12 are presented in this paper), it is not possible to provide an estimate for the entire WHO European Region (53 Member States) or the European Union. An additional four countries (Greece, Hungary, Spain and the former Yugoslav Republic of Macedonia) joined the second COSI data collection round (2009/2010), and it is assumed that more Member States of the WHO European Region will join by the time of the planned third round (school year 2012/2013). In this way, it is expected that routinely measuring body weight and body height in primary-school children, based on a standardized methodology for sampling and data collection, as well as transferring the

collected data to a national or international database, will become common activities in the WHO European Region for the monitoring of the progress and successes of counteracting overweight and obesity in this population group. Moreover, one of the commitments (article 3.2) made by European Member States through the 2006 *European Charter on Counteracting Obesity*[60] could then be considered fulfilled.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

TW conceptualized and drafted the manuscript, drafted the COSI study protocol and conducted all analyses; JvR made substantial contributions to the conception and drafts of both the manuscript and the COSI study protocol as well as interpretation of the results; ASp was involved in critically reviewing the drafts of the manuscript, commented on the COSI study protocol, and contributed with data collection and data cleaning; AR, RH and MK commented on a draft of the manuscript and contributed with data collection and data cleaning; HR made substantial contributions to the development of the study protocol; GS, ASj, AP, UoD, SP, VFS, MW, AY, IMR and JB contributed with data collection and data cleaning. All authors contributed to and approved the final manuscript.

DISCLAIMER

TW and JB are staff members of the World Health Organization. The authors alone are responsible for the content and writing of this paper, which does not necessarily represent the decisions, policy or views of the World Health Organization.

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Supplementary Table 2.1 BMI cut-off values for overweight and obesity for children aged 6–9 years, by sex and age, according to WHO and IOTF definitions

Age	Overweight				Obesity			
years : months	Boys		Girls		Boys		Girls	
	WHO*	IOTF†	WHO*	IOTF†	WHO‡	IOTF§	WHO‡	IOTF§
6:0	16.76	17.55	17.01	17.34	18.52	19.78	19.22	19.65
6:1	16.78	17.57	17.03	17.37	18.55	19.85	19.26	19.72
6:2	16.80	17.60	17.05	17.40	18.59	19.92	19.31	19.79
6:3	16.82	17.62	17.07	17.43	18.63	20.00	19.35	19.86
6:4	16.84	17.65	17.09	17.46	18.67	20.08	19.39	19.93
6:5	16.86	17.68	17.11	17.50	18.70	20.16	19.44	20.01
6:6	16.89	17.71	17.13	17.53	18.75	20.23	19.48	20.08
6:7	16.91	17.74	17.15	17.56	18.79	20.30	19.53	20.15
6:8	16.94	17.78	17.18	17.60	18.83	20.37	19.58	20.22
6:9	16.96	17.81	17.20	17.63	18.88	20.43	19.63	20.29
6:10	16.99	17.85	17.23	17.67	18.92	20.50	19.68	20.36
6:11	17.02	17.88	17.26	17.71	18.97	20.56	19.73	20.44
7:0	17.05	17.92	17.29	17.75	19.02	20.63	19.79	20.51
7:1	17.08	17.96	17.32	17.79	19.07	20.70	19.85	20.59
7:2	17.11	18.00	17.35	17.84	19.12	20.77	19.90	20.67
7:3	17.14	18.04	17.38	17.88	19.17	20.85	19.96	20.75
7:4	17.17	18.08	17.42	17.93	19.22	20.93	20.02	20.83
7:5	17.20	18.12	17.45	17.98	19.27	21.01	20.09	20.92
7:6	17.23	18.16	17.49	18.03	19.33	21.09	20.15	21.01
7:7	17.26	18.20	17.53	18.08	19.38	21.17	20.21	21.10
7:8	17.30	18.25	17.56	18.13	19.44	21.25	20.28	21.19
7:9	17.33	18.29	17.60	18.19	19.50	21.34	20.35	21.28
7:10	17.37	18.34	17.65	18.24	19.56	21.42	20.42	21.38
7:11	17.40	18.39	17.69	18.30	19.62	21.51	20.49	21.47
8:0	17.44	18.44	17.73	18.35	19.68	21.60	20.56	21.57
8:1	17.47	18.49	17.77	18.40	19.74	21.69	20.63	21.67
8:2	17.51	18.54	17.82	18.46	19.80	21.78	20.71	21.77
8:3	17.55	18.60	17.87	18.52	19.86	21.88	20.78	21.87
8:4	17.59	18.65	17.91	18.57	19.93	21.97	20.86	21.97
8:5	17.62	18.70	17.96	18.63	19.99	22.07	20.94	22.08
8:6	17.66	18.76	18.01	18.69	20.06	22.17	21.02	22.18
8:7	17.70	18.82	18.06	18.75	20.12	22.27	21.10	22.28
8:8	17.74	18.87	18.11	18.81	20.19	22.37	21.18	22.39
8:9	17.78	18.93	18.17	18.88	20.26	22.47	21.26	22.49
8:10	17.82	18.98	18.22	18.94	20.33	22.57	21.35	22.60
8:11	17.87	19.04	18.27	19.01	20.40	22.67	21.43	22.70
9:0	17.91	19.10	18.33	19.07	20.47	22.77	21.51	22.81

Supplementary Table 2.1 (*Contd.*)

Age	Overweight				Obesity			
years : months	Boys		Girls		Boys		Girls	
	WHO*	IOTF†	WHO*	IOTF†	WHO‡	IOTF§	WHO‡	IOTF§
9:1	17.95	19.16	18.38	19.13	20.54	22.87	21.60	22.92
9:2	18.00	19.22	18.44	19.20	20.61	22.98	21.68	23.03
9:3	18.04	19.28	18.49	19.26	20.69	23.08	21.77	23.13
9:4	18.09	19.34	18.55	19.32	20.76	23.18	21.86	23.24
9:5	18.13	19.40	18.61	19.39	20.84	23.29	21.94	23.35
9:6	18.18	19.46	18.67	19.45	20.92	23.39	22.03	23.46
9:7	18.23	19.52	18.73	19.52	20.99	23.49	22.12	23.57
9:8	18.28	19.59	18.79	19.58	21.07	23.60	22.21	23.68
9:9	18.33	19.65	18.85	19.65	21.15	23.70	22.30	23.78
9:10	18.38	19.71	18.91	19.72	21.23	23.80	22.39	23.89
9:11	18.43	19.78	18.97	19.79	21.32	23.90	22.48	24.00

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force; WHO, World Health Organization.
* WHO cut-off values for overweight are defined to pass through a BMI of 25 kg/m^2 at the age of 19 years[33]. Overweight is defined as a BMI greater than the given value; † IOTF cut-off values for overweight are defined to pass through a BMI of 25 kg/m^2 at the age of 18 years[3]. Overweight is defined as a BMI equal to or greater than the given value (T. Lobstein, personal communication, October 2011); ‡ WHO cut-off values for obesity are defined to pass through a BMI of 30 kg/m^2 at the age of 19 years[33]. Obesity is defined as a BMI greater than the given value; § IOTF cut-off values for obesity are defined to pass through a BMI of 30 kg/m^2 at the age of 18 years[3]. Obesity is defined as a BMI equal to or greater than the given value (T. Lobstein, personal communication, October 2011).

3

WHO European Childhood Obesity Surveillance Initiative: body mass index and level of overweight among 6–9-year-old children from school year 2007/2008 to school year 2009/2010

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ABSTRACT

Background: The World Health Organization (WHO) Regional Office for Europe has established the Childhood Obesity Surveillance Initiative (COSI) to monitor changes in overweight in primary-school children. The aims of this paper are to present the anthropometric results of COSI Round 2 (2009/2010) and to explore changes in body mass index (BMI) and overweight among children within and across nine countries from school years 2007/2008 to 2009/2010.

Methods: Using cross-sectional nationally representative samples of 6–9-year-olds, BMI, anthropometric Z-scores and overweight prevalence were derived from measured weight and height. Significant changes between rounds were assessed using variance and t-tests analyses.

Results: At Round 2, the prevalence of overweight (including obesity; WHO definitions) ranged from 18% to 57% among boys and from 18% to 50% among girls; 6–31% of boys and 5–21% of girls were obese. Southern European countries had the highest overweight prevalence. Between rounds, the absolute change in mean BMI (range: from –0.4 to +0.3) and BMI-for-age Z-scores (range: from –0.21 to +0.14) varied statistically significantly across countries. The highest significant decrease in BMI-for-age Z-scores was found in countries with higher absolute BMI values and the highest significant increase in countries with lower BMI values. The highest significant decrease in overweight prevalence was observed in Italy, Portugal and Slovenia and the highest significant increase in Latvia and Norway.

Conclusions: Changes in BMI and prevalence of overweight over a two-year period varied significantly among European countries. It may be that countries with higher prevalence of overweight in COSI Round 1 have implemented interventions to try to remedy this situation.

BACKGROUND

Through the *European Charter on Counteracting Obesity*, Member States in the European Region of the World Health Organization (WHO) declared in 2006 their commitment to strengthen action on counteracting obesity and to place this issue high on the political agenda of their governments. Article 2.2 of the Charter states that "Curbing the epidemic and reversing the trend are the ultimate goal of action in the Region. Visible progress, especially relating to children and adolescents, should be achievable in most countries in the next 4–5 years and it should be possible to reverse the trend by 2015 at the latest". Moreover, article 3.2 specifies that "A process needs to be put together to develop internationally comparable core indicators for inclusion in national health surveillance systems. These data could then be used for advocacy, policy-making and monitoring purposes. This would also allow for regular evaluation and review of policies and actions and for the dissemination of findings to a wide audience"[1]. The establishment of the WHO European Childhood Obesity Surveillance Initiative (COSI) in 2006 was a response to this Charter, which was signed at the WHO European Ministerial Conference on Counteracting Obesity in Istanbul, Turkey[2]. The importance of such surveillance mechanisms was reinforced as one of the strongest dimensions in the *Vienna Declaration on Nutrition and Noncommunicable Diseases in the Context of Health 2020*[3], which was endorsed at the sixty-third session of the WHO Regional Committee for Europe in September 2013[4].

COSI routinely measures overweight and obesity prevalence of primary-school children aged 6–9 years, in order to monitor progress with curbing excess body weight in this population group and to permit intercountry comparisons within the WHO European Region. The first COSI data collection round took place during the school year 2007/2008 (Round 1) in which 13 countries participated[5]. A second COSI data collection round took place during the school year 2009/2010 (Round 2) and some of the participating countries have already published the national data analyses of Round 2[6–10].

The aim of this paper is twofold: 1) to present the findings of COSI Round 2 and investigate whether differences exist in mean values of anthropometric measurements (weight, height), indices (body mass index (BMI) and Z-scores) and prevalence estimates across countries and between boys and girls; and 2) to assess which countries are on track to achieving the Charter's ultimate goal by studying the direction and magnitude of the change in mean anthropometric values and overweight prevalence estimates from Round 1 to Round 2.

METHODS

COSI Round 2 (2009/2010) was conducted in 15 countries: Belgium, Cyprus, Czech Republic, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia, Spain, and the former Yugoslav Republic of Macedonia. All Round 2 countries except for Cyprus and Malta delivered their 2009/2010 data to the WHO-COSI database in line with the COSI protocol and thus data from 13 countries were used for the present analysis. The implementation characteristics of COSI Round 1 (2007/2008) were described in detail elsewhere[5].

Protocol development

A common protocol was developed throughout 2007 by the WHO Regional Office for Europe and Member States participating in COSI, and it was used for both rounds[11]. Two protocol changes in recording procedures were made for Round 2: precise recording of the time of measurement was made optional, and a mandatory variable to indicate whether measurements took place before or after lunch was added. In addition, children were no longer routinely asked to go to the toilet before the measurements[12].

Study population and sampling design

Countries that participated in Round 1 could decide for Round 2 to select a new nationally representative sample of schools or to go back to the same schools that were selected in Round 1 and select randomly the classes at these sentinel sites. Four countries (Ireland, Lithuania, Norway and Portugal) chose the sentinel site approach. The entire population of interest was included by Belgium (Flanders only) and new nationally representative samples were taken by the other eight countries (see Supplementary Table 3.1).

Age groups chosen

Given the differences among countries in school systems, the age of children entering the first class of primary school (reception year), and the number of children repeating a grade, it was difficult to implement a uniform sampling approach that was applicable in every country. Age was therefore taken as the first condition for the sampling procedures. Countries were free to select one or more of the following four defined COSI age groups: 6.0–6.9, 7.0–7.9, 8.0–8.9 or 9.0–9.9 years. Since children of this age in all countries are enrolled in primary schools, the school population was therefore taken to be representative of the total population in these age groups.

Stratification

Stratification of the primary sampling unit (PSU) was applied if it was expected that differences in anthropometric measurements and indices across strata would be observed. This was

done by eight countries: the Czech Republic by region and level of urbanization; Greece by prefecture; Hungary by county; Italy by region; Latvia by level of urbanization and language of instruction; Lithuania by district and level of urbanization; Spain by geopolitical region and size of city/village; and the former Yugoslav Republic of Macedonia by level of urbanization.

Sampling units

Cluster sampling was employed by the eight countries that drew a new sample whereby the PSU was the primary school or the class (except in the Czech Republic, where the PSU was composed of paediatric clinics, since COSI was attached to the mandatory health checks that are performed by paediatricians). Primary schools and classes were selected randomly from the list of all primary schools (public, private and special schools) centrally available in each country through the Ministry of Education or at the national school registry (or national list of primary care paediatricians). If less than about 1% of the target children were enrolled in private or special schools (e.g. schools for children with learning disability or visual impairment), countries had the choice of excluding these schools from the sampling frame. If the majority of the children of the targeted age group were in the same grade, then the class was drawn from within that grade level. If the targeted age group was spread across grades, however, all grades where most children from this age group were present were sampled. In every sampled class, all children were invited to participate.

Sample size

Rudolf *et al*. suggest using the standard deviation (SD) scores or Z-scores of a BMI distribution to demonstrate whether a halt in the rise in overweight or obesity is achieved[13]. The calculated sample size of ≈2300 children per age group was based on an 80% power to detect a minimum difference of 0.10 Z-score in mean BMI per year at a two-sided 5% significance level. To achieve the same precision with a cluster sample design as with a simple random sample, the minimum final effective sample size should be ≈2800 children per age group, whereby a design effect of 1.2 was applied[14]. Supplementary Table **3.2** shows by country the number of children who were invited to participate in Round 2, who were measured, who had complete information on age, sex, weight and height, and who fell within the targeted age group. A total of 224 920 children aged 6–9 years were included in the data analyses (114 457 boys and 110 463 girls).

Data collection procedures

Countries decided on the measurement period. Data collection, however, was avoided during the first two weeks of a school term or immediately after a major holiday. Taking the local arrangements, circumstances and budget into account, countries chose the most appropriate professionals to collect data from the children, hereafter called examiners. Supplementary

Table 3.3 gives a summary of the application of the COSI protocol characteristics in each country in Round 2.

Ethics approval procedures

The COSI protocol is in accordance with the *international ethical guidelines for biomedical research involving human subjects*[15]. Depending on local circumstances, the procedures were also approved by local ethical committees. This was not needed in four countries because data collection procedures were part of legislation (Belgium), a compulsory school programme (Slovenia), a National Annual Program of Public Health (the former Yugoslav Republic of Macedonia) or were regulated by the National Health Authority and Regional Health Authorities (Spain). The local committees in the other nine countries were: Czech Republic: the Institutional Ethical Committee of the Institute of Endocrinology; Greece: the Ethics Committee of the Alexander Technological Educational Institute of Thessaloniki; Hungary: the Scientific and Research Ethics Committee of the Medical Research Council; Ireland: the Research Ethics Committee of the University College Dublin; Italy: the Institutional Ethical Committee of the Italian National Institute of Health; Latvia: Central Medical Ethics Committee; Lithuania: Lithuanian Bioethics Committee; Norway: Regional Committee for Medical and Health Research Ethics; and Portugal: Portuguese Data Protection Authority. Detailed information on the ethical clearance procedures in each country is included in Supplementary Text 3.4. Parents were always fully informed about all study procedures and their informed consent approach (passive or active by one or two parents) was obtained. Children's consent was always obtained prior to the measurements.

Anthropometric measurements

Prior to data collection, all examiners were trained in measuring weight and height using WHO standardized techniques[16]. Children were asked to take off their shoes and socks as well as all heavy clothing (coats, sweaters, jackets, etc.) and to remove items such as wallets, mobile phones or key chains. Body weight was measured to the nearest 0.1 kg with portable digital (mainly manufacturer-calibrated) scales and body height was measured standing upright to the nearest 0.1 cm with portable stadiometers. Body weight was then adjusted for the weight of the clothes worn. The average weights of types of clothing were provided by each country. Where possible, the same anthropometric equipment was used throughout a country. Anthropometric measurements were preferably done in the mornings before lunch time, although this had not always been feasible.

Data elaboration

All country datasets were reviewed in a standard manner at the Regional Office for inconsistencies and completeness before they were merged for the intercountry analyses.

The final dataset included children with informed consent and complete information on age, sex, weight and height. Children were excluded from the final dataset if their age did not fall within the targeted age group.

The child's age (in years) was calculated using the formula: (date of measurement minus date of birth (expressed in days))/365.25. When a complete date of birth was not provided but only the month and year of birth, then the child's age (in years) was calculated by dividing the number of months between the date of birth and the date of measurement by 12 (this was done for the entire Belgian dataset). BMI was calculated using the formula: weight (kg) divided by height squared (m^2).

The 2007 WHO recommended cut-offs for school-age children and adolescents were used to compute height-for-age (H/A), weight-for-age (W/A) and BMI-for-age (BMI/A) Z-scores and to interpret anthropometric indicators[17,18], whereby stunting and severe stunting were defined as the proportion of children with a H/A value below –2 Z-scores and below –3 Z-scores, respectively, relative to the 2007 WHO growth reference median[17]. Underweight and severe underweight were defined as the proportion of children with a W/A value below –2 Z-scores and below –3 Z-scores, respectively. Thinness and severe thinness were defined as the proportion of children with a BMI/A value below –2 Z-scores and below –3 Z-scores, respectively. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively. Overweight and obesity were also estimated using the IOTF cut-off points[19], as they are widely used in the WHO European Region (see Supplementary Table 3.5).

According to WHO definitions, the prevalence estimates for stunted children include those who are severely stunted, the prevalence estimates for underweight children include those who are severely underweight, the prevalence estimates for thin children include those who are severely thin, and the prevalence estimates for overweight children include those who are obese[16].

Children with biologically implausible (or extreme) values were excluded from the analysis[18]: W/A values below –6 or above +5 Z-scores; H/A values below –6 or above +6 Z-scores; and BMI/A values below –5 or above +5 Z-scores relative to the 2007 WHO growth reference median.

Statistical analysis

A *P* value of < 0.05 was used to define statistical significance. All statistical analyses, except the Games–Howell *post hoc* tests, were performed in Stata version 10.1 (StataCorp, College Station, TX, USA). The latter was performed in SPSS version 20.0 (IBM, Armonk, NY, USA).

Round 2

Sampling weights to adjust for the applied sampling design, oversampling and non-response rate of Round 2 were available for only four countries. For the other countries, these could

not be calculated for various reasons. For instance, the registration of the children in schools and classes was not entirely complete. Hence, the analyses were performed unweighted. Means ± SDs were calculated for all measurements (weight and height) and anthropometric indices (BMI, W/A, H/A and BMI/A Z-scores) by age group, sex and country. For each country-specific dataset, these six continuous variables were tested by age group for normality using normal quantile–quantile plots. Weight and BMI were found to be highly positively skewed in all datasets. They were therefore transformed to attain normality and their transformed values were used for the intercountry comparisons. Using the command 'ladder' in Stata, the best option suggested was inverse transformation for weight and 1/square transformation for BMI for the majority of the datasets. Although the distribution of W/A and BMI/A Z-scores was also skewed to the right, the command 'ladder' showed no need to apply transformations to normalize them.

The homogeneity of variances was tested using Levene's test[20]. Since the data showed heterogeneity of variances between countries and because of an unbalanced design (unequal group sizes), the main effects of country and sex and their interaction on all mean anthropometric values was assessed using two-way analysis of variance (ANOVA), with the Games–Howell *post hoc* test for the multiple comparisons between countries[21]. This was done separately for all age groups because not every country had included all age groups. In the case of an interaction effect, a one-way ANOVA was performed to assess significant differences across countries by sex and between sexes by country for all four age groups.

Prevalence estimates are presented as percentages. Within each age group, the chi-squared test was used to determine differences in the prevalence estimates across countries for the total group and for boys and girls separately. If the chi-squared test was found significant, the Marascuilo procedure was used for the multi-group comparisons of proportions between countries[22]. In addition a chi-squared test was used to determine the statistical significance of differences in the prevalence estimates between boys and girls within each age group as well as to assess a linear trend in the prevalence estimates with increasing age for the seven countries with multiple age groups selected (Belgium, Greece, Ireland, Italy, Lithuania, Slovenia, and Spain).

Changes from Round 1 to Round 2

The absolute change in mean values for all measurements (weight and height) and anthropometric indices (BMI, W/A, H/A and BMI/A Z-scores) was calculated for the nine countries that participated in both rounds (Belgium, Czech Republic, Ireland, Italy, Latvia, Lithuania, Norway, Portugal, and Slovenia), by age group and sex. A two-way ANOVA was applied to assess the interaction effect of country and round on all mean anthropometric values, for boys and girls separately. In the case of no significant interaction effect, two-way ANOVA without the interaction term (additive model) was performed to assess the main effects of country and round on the values. By age group and for boys and girls separately,

Levene's test[20] was applied to assess the homogeneity of variances between the two rounds. If a significant interaction effect was found by the two-way ANOVA, the unpaired t-test (equal variance) or the unpaired Welch's t-test (unequal variance) was performed to assess whether the difference in mean values between the two rounds in each country was statistically significant.

A z test for two independent proportions was used to determine the statistical significance of differences in the prevalence estimates between the two rounds by country and age group.

RESULTS

COSI Round 2 (2009/2010)

Weight, height, body mass index, weight-for-age, height-for-age and body mass index-for-age Z-scores

Mean values for weight and W/A Z-score are presented in Table 3.1, mean values for height and H/A Z-score in Table 3.2 and mean values for BMI and BMI/A Z-score in Table 3.3. All mean Z-scores were positive. Weight and height increased with age and boys were taller and heavier than girls in all age groups (where statistically significant differences between boys and girls were found). Based on the values found in countries that targeted multiple age groups, BMI also increased with age (except in Italian girls). Mean BMI/A Z-scores close to the +1 Z-score curve values of the 2007 WHO growth reference were found in three countries (Greece, Italy and Spain). Median values of weight and BMI are available in Supplementary Table 3.6.

Two-way ANOVA showed a statistically significant interaction effect of country and sex on most anthropometric values (BMI/A Z-score for each of the four age groups ($P < 0.05$); inverse-transformed weight ($P < 0.001$), W/A Z-score ($P < 0.0001$) and 1/square-transformed BMI ($P < 0.0001$) for the 7-, 8- and 9-year-old groups; H/A Z-score for the 8-year-old group ($P < 0.05$) and height for the 8- and 9-year-old groups ($P < 0.05$)). Because significant results were found in all age groups, one-way ANOVA analyses were performed to assess within each age group the country effect for boys and girls separately and the sex effect for each country separately. Results from the one-way ANOVA analyses are also presented in Tables 3.1–3.3. The main effect of country ($P < 0.0001$) on all mean values and the main effect of sex ($P < 0.05$) on most mean values were statistically significant. Subsequently, Games–Howell *post hoc* tests were performed for boys and girls separately within each age group to study the differences between countries in more detail (countries within each sex-age group that share the same superscript letter do not statistically significantly differ from each other).

Based on mean BMI/A Z-score values, three categories of countries could be determined. One group of countries (Belgium, Czech Republic, Hungary, Latvia, Lithuania and Norway)

Table 3.1 Mean (SD) values of weight and weight-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 2 (2009/2010), by age and country†

Age group and country	Weight‡ (*kg*)		W/A Z-score	
	Boys	Girls	Boys	Girls
	Mean (SD)			
6-year-olds	§	§	§	§
BEL	23.0 (3.7)¶,a	22.7 (3.9)a	0.35 (1.06)a	0.33 (1.00)a
SVN	24.9 (4.6)¶,b	24.4 (4.6)b	0.70 (1.20)¶,b	0.62 (1.10)b
ESP	24.9 (4.6)¶,b	24.5 (4.6)b	0.81 (1.19)b	0.72 (1.09)c
7-year-olds	§	§	§	§
BEL	25.8 (5.0)¶,a	25.7 (5.4)a	0.40 (1.20)a	0.40 (1.13)a
CZE	26.0 (4.8)¶,a,b	25.3 (5.1)a	0.63 (1.17)¶,b,c	0.51 (1.12)a,b,c
GRC	29.5 (5.8)¶,c	29.1 (6.1)b	1.17 (1.27)¶,d	1.05 (1.15)d
HUN	26.7 (5.5)b,d,e	26.4 (5.8)a,c	0.57 (1.28)a,b	0.54 (1.22)a,b,c
IRL	26.0 (4.2)¶,a,d	25.6 (4.6)a,c	0.53 (1.04)a,b	0.51 (1.02)a,b,c
LVA	27.4 (5.3)¶,f,g	26.5 (5.3)c,d	0.63 (1.18)¶,b	0.45 (1.08)a,c
LTU	27.6 (5.3)¶,f	27.0 (5.5)d	0.68 (1.17)¶,b,c	0.55 (1.09)b,c
PRT	27.0 (5.5)d,e,g	27.2 (5.7)d,e	0.61 (1.25)b	0.66 (1.15)b,e
SVN	27.8 (5.7)¶,f	27.1 (5.8)d	0.78 (1.25)¶,c	0.64 (1.14)b
ESP	28.5 (5.7)¶,h	27.9 (5.8)e	0.96 (1.24)¶,e	0.81 (1.13)e
MKD	27.6 (6.4)¶,e,f	26.5 (6.4)c	0.70 (1.46)¶,b,c	0.50 (1.32)a,c
8-year-olds	§	§	§	§
BEL	29.3 (5.5)¶,a	29.1 (5.9)a	0.45 (1.10)¶,a	0.40 (1.06)a
ITA	32.3 (7.3)¶,b	31.6 (7.3)b	0.90 (1.31)¶,b	0.70 (1.22)b
NOR	30.2 (5.7)¶,c	29.6 (5.6)c	0.69 (1.11)¶,c	0.56 (1.00)c
SVN	31.8 (7.0)¶,d	31.1 (7.1)b	0.90 (1.26)¶,b	0.72 (1.16)b
ESP	31.7 (6.4)b,d	31.5 (6.7)b	0.91 (1.18)¶,b	0.79 (1.12)b
9-year-olds	§	§	§	§
BEL	32.8 (7.3)a	32.9 (7.6)a	0.46 (1.18)¶,a	0.36 (1.18)a
GRC	38.4 (8.9)¶,b	37.6 (9.1)b	1.30 (1.21)¶,b	1.02 (1.23)b
IRL	33.0 (6.3)¶,a,c	32.2 (6.9)a	0.63 (1.05)¶,c	0.37 (1.13)a,c
ITA	33.9 (7.8)¶,c	32.9 (7.6)a	0.79 (1.28)¶,d	0.53 (1.21)c
LTU	34.7 (7.5)¶,d	33.7 (7.3)c	0.66 (1.12)¶,c	0.40 (1.09)a
SVN	34.2 (7.9)c,d	33.8 (8.0)c	0.85 (1.24)¶,d,e	0.68 (1.23)d
ESP	35.9 (7.7)¶,e	35.2 (7.7)d	0.97 (1.13)¶,e	0.73 (1.12)d

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NOR, Norway; PRT, Portugal (all regions except Madeira); SD, standard deviation; SVN, Slovenia; W/A, weight-for-age; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

a,b,c,d,e,f,g,h Within each sex-age group (e.g. 6-year-old girls), mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 6-year-old

Table 3.1 (*Contd.)*
girls, each mean W/A Z-score value is significantly different from the other two whereas the value of Belgian 6-year-old boys differed significantly from the other two and no significant difference was found between Slovenian and Spanish 6-year-old boys; * Based on the 2007 WHO growth reference for school-age children and adolescents[17]; † Body weight was adjusted for clothes worn when measured and children with a W/A Z-score < –6 or > +5 were excluded; ‡ Non-normally distributed and underwent inverse transformation prior to ANOVA and Games–Howell *post hoc* tests; § Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA; $P < 0.0001$); ¶ Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA; $P \leq 0.05$).

consistently had values (in both boys and girls as well as in multiple age groups when applicable) between the expected 2007 WHO growth reference value and 0.5 SD away from this reference median value. A second group of countries (Greece, Italy, Portugal and Spain) consistently had values more than 0.5 SD away from the 2007 WHO growth reference median. The third group consisted of countries that could not easily be categorized in one of these two groups, because the mean BMI/A Z-score value of boys was more than 0.5 SD while the value of girls was less than 0.5 SD away from the median of the growth reference population (the former Yugoslav Republic of Macedonia) or the values differed across age groups (Ireland and Slovenia).

Prevalence of stunting, underweight and thinness

Stunting, underweight and thinness were rare in all countries. Most values for severe stunting, severe underweight and severe thinness were below 0.2%. All values for stunting and underweight and most values for thinness were below 2.3%. Values for thinness greater than 2.3%, but still close to what is expected in a normally distributed population, were found in Lithuanian 9-year-old girls (3.2%), Slovenian 6-year-old boys (3.1%), Slovenian 7-year-old boys (2.9%) and girls (2.4%) and 7-year-old boys and girls (both 2.5%) of the former Yugoslav Republic of Macedonia.

Prevalence of overweight and obesity

Table 3.4 presents the proportions of overweight and obese boys and girls in each age group and country, based on both the WHO and IOTF definitions. In the six countries with a mean BMI/A Z-score value between the expected reference median value and 0.5 SD away from this value, the prevalence of overweight (including obesity and based on WHO definitions) varied from 18% to 29% (IOTF: 11–19%) in boys and from 18% to 28% (IOTF: 15–24%) in girls, and the prevalence of obesity varied from 6% to 14% (IOTF: 3–7%) in boys and from 5% to 10% (IOTF: 4–8%) in girls. In the four countries with BMI/A Z-score values more than 0.5 SD away from the 2007 WHO growth reference median, the prevalence of overweight varied from 32% to 57% (IOTF: 23–45%) in boys and from 35% to 50% (IOTF: 30–42%) in girls, whereas the prevalence of obesity varied from 14% to 31% (IOTF: 8–15%) in boys and from 12% to 21% (IOTF: 8–15%) in girls.

Table 3.2 Mean (SD) values of height and height-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 2 (2009/2010), by age and country†

Age group and country	Height (*cm*)		H/A Z-score	
	Boys	Girls	Boys	Girls
	Mean (SD)			
6-year-olds	‡	‡	‡	‡
BEL	120.5 (5.3)[§,a]	119.6 (5.3)[a]	0.36 (0.99)[§,a]	0.34 (0.95)[a]
SVN	124.4 (5.3)[§,b]	123.5 (5.5)[b]	0.87 (0.99)[b]	0.88 (0.99)[b]
ESP	121.4 (5.5)[§,c]	120.5 (5.5)[c]	0.45 (1.01)[c]	0.41 (1.00)[a]
7-year-olds	‡	‡	‡	‡
BEL	125.6 (6.0)[§,a]	124.7 (6.0)[a]	0.32 (1.02)[§,a]	0.29 (1.00)[a]
CZE	126.0 (5.4)[§,a,b,c]	124.8 (5.7)[a,b,c]	0.65 (1.00)[b,c,d,e]	0.57 (1.04)[b,c]
GRC	128.5 (5.8)[§,d]	127.8 (5.9)[d,e]	0.71 (1.07)[b,f]	0.70 (1.03)[c,d]
HUN	127.2 (5.9)[§,e,f]	126.0 (5.9)[f]	0.56 (1.07)[b,e,g]	0.51 (1.04)[b,e]
IRL	125.5 (5.2)[§,a,c]	123.8 (5.4)[b]	0.35 (0.93)[a,h]	0.23 (0.96)[a,f]
LVA	128.7 (5.6)[§,d]	127.3 (5.7)[d]	0.62 (1.00)[§,b,e]	0.51 (0.98)[b,e]
LTU	129.5 (5.7)[§,g]	128.6 (5.8)[g]	0.76 (1.02)[c,f]	0.72 (1.00)[d]
PRT	126.4 (5.5)[§,b,c,e]	125.5 (5.7)[c,f]	0.35 (0.97)[a,h]	0.33 (0.98)[a,f]
SVN	129.0 (5.5)[§,d,g]	128.1 (5.6)[e,g]	0.81 (0.95)[f]	0.78 (0.95)[d]
ESP	127.1 (5.6)[§,e,f]	126.0 (5.7)[f]	0.47 (0.98)[g,h]	0.40 (0.96)[e,f]
MKD	127.3 (6.4)[§,f]	126.2 (6.4)[f]	0.52 (1.16)[d,e,g]	0.48 (1.11)[b,e]
8-year-olds	‡	‡	‡	‡
BEL	132.6 (5.9)[§,a]	131.8 (6.0)[a]	0.48 (0.98)[§,a]	0.41 (0.98)[a,b]
ITA	133.1 (6.0)[§,b]	132.0 (6.1)[b]	0.41 (1.00)[§,b]	0.29 (1.01)[c]
NOR	133.1 (5.7)[§,b,c]	131.8 (5.8)[a,b]	0.63 (0.96)[§,c]	0.48 (0.94)[a]
SVN	134.4 (5.8)[§,d]	133.6 (5.8)[c]	0.76 (0.95)[§,d]	0.68 (0.94)[d]
ESP	132.4 (6.0)[§,a,c]	131.8 (5.9)[a,b]	0.42 (0.99)[a,b]	0.37 (0.96)[b,c]
9-year-olds	‡	‡	‡	‡
BEL	137.3 (6.5)[§,a]	136.9 (6.8)[a]	0.40 (1.01)[§,a]	0.28 (1.03)[a]
GRC	139.9 (6.7)[§,b]	139.3 (6.7)[b]	0.74 (1.07)[§,b]	0.59 (1.07)[b]
IRL	136.5 (5.8)[§,c]	134.9 (6.5)[c]	0.37 (0.94)[§,a,c]	0.11 (1.04)[c]
ITA	135.6 (6.0)[§,c]	134.7 (6.3)[c]	0.32 (0.99)[§,c]	0.15 (1.02)[c]
LTU	140.5 (6.3)[§,b]	139.9 (6.4)[b]	0.72 (1.00)[§,b]	0.57 (0.99)[b]
SVN	137.7 (6.0)[§,a]	137.0 (6.2)[a]	0.67 (0.99)[§,b]	0.55 (1.02)[b]
ESP	137.8 (6.2)[§,a]	136.9 (6.6)[a]	0.43 (0.96)[§,a]	0.25 (0.99)[a,c]

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; H/A, height-for-age; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NOR, Norway; PRT, Portugal (all regions except Madeira); SD, standard deviation; SVN, Slovenia; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d,e,f,g,h] Within each sex-age group (e.g. 6-year-old boys), mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 6-year-old

Table 3.2 *(Contd.)*
boys, each mean H/A Z-score value is significantly different from the other two whereas the value of Slovenian 6-year-old girls differed significantly from the other two and no significant difference was found between Belgian and Spanish 6-year-old girls; * Based on the 2007 WHO growth reference for school-age children and adolescents[17]; † Children with a H/A Z-score < –6 or > +6 were excluded; ‡ Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA; $P < 0.0001$); § Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA; $P < 0.05$).

The chi-squared test comparing the prevalence estimates across countries was significant for all age groups (P < 0.001 for boys and girls separately). The Marascuilo procedure was then used to study country differences for each age group (see Table 3.4; countries within each sex-age group that share the same superscript letter do not statistically significantly differ from each other).

Based on WHO definitions, the observed linear increasing trend in the prevalence of overweight with increasing age was significant for Belgian boys and girls (both $P < 0.001$), Greek boys ($P < 0.001$) and girls ($P < 0.01$), Irish boys ($P < 0.05$), Slovenian boys and girls (both $P < 0.001$), and Spanish boys ($P < 0.001$) and girls ($P < 0.01$). The increasing obesity trend with increasing age was significant in Belgian boys and girls (both $P < 0.001$), Greek boys ($P < 0.001$), Slovenian boys and girls (both $P < 0.001$), and Spanish boys ($P = 0.001$). The observed decreasing trend in Italy with increasing age was significant for overweight and obesity in girls ($P < 0.001$). Fewer statistically significant results were found when performing the analyses based on IOTF definitions.

Figure 3.1 illustrates the geographical distribution of the prevalence of overweight and obesity found in Round 2 in 13 countries, grouped by subregions, of the WHO European Region (sexes combined and based on WHO definitions).

Changes from COSI Round 1 (2007/2008) to COSI Round 2 (2009/2010)

The absolute change in mean values of weight, height and BMI from Round 1 to Round 2 is presented in Table 3.5 and the absolute change in mean values of W/A, H/A and BMI/A Z-score in Table 3.6. The direction (increase, decrease or no change) and magnitude of this change differed by country, which is shown by the results of the two-way ANOVA with interaction (country*round). This analysis showed statistically significant results for almost all mean values of BMI (Table 3.5) and BMI/A Z-score (Table 3.6). Two-way ANOVA using the additive model was then applied for the mean values with no statistical significant interaction effect. The main effect of country ($P < 0.0001$) on all these values except for weight in 9-year-old girls were statistically significant. The main effect of data collection round ($P < 0.05$) on all weight, BMI and BMI/A Z-score values as well as on one W/A Z-score (6-year-old boys) and some H/A Z-score (7-year-old boys and 9-year-old girls) values were statistically significant. The unpaired t-test showed statistically significant difference in the change in mean values between the two rounds in some age-sex groups in some countries. When this difference

Table 3.3 Mean (SD) values of BMI and BMI-for-age Z-scores* of boys and girls aged 6–9 years in COSI Round 2 (2009/2010), by age and country†

Age group and country	BMI‡ (*kg/m²*)		BMI/A Z-score	
	Boys	Girls	Boys	Girls
	Mean (SD)			
6-year-olds	§	§	§	§
BEL	15.8 (1.7)[a]	15.8 (1.9)[a]	0.16 (1.08)[a]	0.16 (1.02)[a]
SVN	16.0 (2.2)[a]	15.9 (2.2)[a]	0.21 (1.34)[a]	0.15 (1.16)[a]
ESP	16.8 (2.2)[b]	16.8 (2.4)[b]	0.78 (1.25)[¶,b]	0.66 (1.15)[b]
7-year-olds	§	§	§	§
BEL	16.3 (2.2)[a]	16.4 (2.5)[a]	0.27 (1.23)[a]	0.29 (1.14)[a]
CZE	16.3 (2.3)[a,b]	16.2 (2.4)[a]	0.31 (1.29)[a,b]	0.23 (1.16)[a,b]
GRC	17.7 (2.7)[c]	17.7 (2.8)[b]	1.06 (1.31)[¶,c]	0.90 (1.15)[c]
HUN	16.4 (2.5)[a,b,d,e]	16.5 (2.7)[a,c]	0.30 (1.37)[a,b]	0.33 (1.23)[a,b,d]
IRL	16.5 (2.0)[d,e,f]	16.6 (2.1)[c,d]	0.46 (1.05)[b,d]	0.50 (1.00)[d,e]
LVA	16.5 (2.3)[¶,a,b,e,g]	16.2 (2.4)[a]	0.34 (1.25)[¶,a,b]	0.18 (1.12)[b]
LTU	16.4 (2.4)[¶,a,b,e]	16.2 (2.5)[a]	0.31 (1.27)[¶,a,b]	0.17 (1.15)[b]
PRT	16.8 (2.5)[¶,f]	17.1 (2.7)[d,e]	0.56 (1.28)[d]	0.64 (1.15)[e,f]
SVN	16.6 (2.6)[¶,b,e,g]	16.4 (2.6)[a]	0.40 (1.38)[¶,b,d]	0.25 (1.22)[a,b]
ESP	17.5 (2.7)[c]	17.4 (2.7)[b,e]	0.94 (1.31)[¶,c]	0.76 (1.18)[c,f]
MKD	16.9 (2.9)[¶,f,g]	16.5 (2.9)[a]	0.55 (1.54)[¶,d]	0.29 (1.33)[a,b]
8-year-olds	§	§	§	§
BEL	16.5 (2.3)[¶,a]	16.7 (2.5)[a]	0.21 (1.17)[a]	0.22 (1.09)[a]
ITA	18.1 (3.1)[¶,b]	18.0 (3.2)[b]	0.89 (1.37)[¶,b]	0.70 (1.23)[b]
NOR	16.9 (2.5)[c]	16.9 (2.3)[c]	0.43 (1.23)[c]	0.39 (1.01)[c]
SVN	17.5 (3.0)[¶,d]	17.3 (3.0)[c]	0.64 (1.37)[¶,d]	0.46 (1.22)[c]
ESP	18.0 (2.7)[b]	18.0 (2.9)[b]	0.92 (1.23)[¶,b]	0.77 (1.11)[b]
9-year-olds	§	§	§	§
BEL	17.3 (2.9)[a]	17.4 (3.0)[a]	0.31 (1.28)[¶,a]	0.26 (1.19)[a]
GRC	19.5 (3.5)[¶,b]	19.2 (3.6)[b]	1.26 (1.26)[¶,b]	0.93 (1.23)[b]
IRL	17.6 (2.5)[c]	17.5 (2.8)[a,c]	0.58 (1.09)[¶,c]	0.41 (1.09)[a,c]
ITA	18.3 (3.3)[¶,d]	18.0 (3.2)[c]	0.83 (1.38)[¶,d]	0.57 (1.22)[d]
LTU	17.5 (2.9)[¶,c]	17.1 (2.8)[d]	0.37 (1.23)[¶,a]	0.09 (1.16)[e]
SVN	17.8 (3.1)[c]	17.9 (3.4)[c]	0.64 (1.32)[¶,c]	0.51 (1.25)[c,d]
ESP	18.8 (3.1)[e]	18.6 (3.2)[e]	1.00 (1.21)[¶,e]	0.76 (1.13)[f]

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NOR, Norway; PRT, Portugal (all regions except Madeira); SD, standard deviation; SVN, Slovenia; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d,e] Within each sex-age group (e.g. 9-year-old boys), mean values that share the same letter superscript do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the 9-year-old

Table 3.3 *(Contd.)*
boys, the mean BMI/A Z-scores of Greek, Italian and Spanish boys significantly differ from the other six, whereas the values of Belgian and Lithuanian boys do not differ significantly from each other as well as the values of Irish and Slovenian boys; * Based on the 2007 WHO growth reference for school-age children and adolescents[17]; † Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded; ‡ Non-normally distributed and underwent 1/square transformation prior to ANOVA and Games–Howell *post hoc* tests; § Statistically significant difference of mean value across countries for the indicated age group (one-way ANOVA; $P < 0.0001$); ¶ Statistically significant difference of mean value between boys and girls for the indicated country (one-way ANOVA; $P < 0.05$).

was statistically significant for both boys and girls, the direction of the change was the same for both sexes.

The absolute change in overweight and obesity prevalence estimates (based on WHO definitions[17]) from Round 1 to Round 2 is presented in Table 3.7. The prevalence of overweight (including obesity) statistically significantly decreased in Belgian 6-year-old boys, Italian 8-year-old boys and girls, Italian 9-year-old boys, Portuguese 7-year-old boys, Slovenian 6- and 7-year-old boys and Slovenian 7-year-old girls. A statistically significant absolute increase in overweight prevalence was observed in Latvian 7-year-old girls and Norwegian 8-year-old boys. The prevalence of obesity statistically significantly decreased in Italian 8-year-old boys, Italian 9-year-old boys and girls and Slovenian 7-year-old boys. A Statistically significant absolute increase in obesity prevalence was observed in Latvian 7-year-old boys and girls and Norwegian 8-year-old boys.

DISCUSSION

COSI Round 2 (2009/2010)

When adjusting weight (Table 3.1) and height (Table 3.2) for age, positive W/A and H/A Z-score values were found in all countries. This means that the country values were higher than the population median values of the 2007 WHO growth reference[17] and thus the COSI children were heavier and taller than the reference population.

All country mean BMI/A Z-score values (Table 3.3) were positive – thus higher than the 2007 WHO growth reference population[17] – but varied largely among the countries. Grouping of countries on the basis of having or not having a mean value of 0.5 SD away from the reference median suggests the presence of a north–south gradient with the highest BMI/A Z-score values found in southern European countries. Categorization of countries based on prevalence estimates (regardless of WHO or IOTF definitions) showed similar groups of countries. These findings also suggest the presence of a north–south gradient with the highest overweight and obesity prevalence estimates noted in southern European countries.

Table 3.4 Prevalence of overweight (including obesity) and obesity in boys and girls aged 6–9 years in COSI Round 2 (2009/2010), by age and country

Age group and country	Prevalence of overweight (including obesity) (%)				Prevalence of obesity (%)			
	WHO definition*		IOTF definition†		WHO definition*		IOTF definition†	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6-year-olds°	‡	‡	‡	‡	‡	‡	‡	‡
BEL	18.0[a]	18.2[a]	10.8[a]	15.1[a]	5.8[a]	5.2[a]	2.8[a]	4.2[a]
SVN	23.5[b]	21.7[b]	16.5[b]	18.3[b]	10.0[b]	6.8[b]	5.2[b]	5.8[b]
ESP	38.2[c]	34.5[c]	25.6[c]	30.0[c]	15.1[c]	12.8[c]	8.7[c]	9.9[c]
7-year-olds°°	‡	‡	‡	‡	‡	‡	‡	‡
BEL	23.1[a]	24.1[a]	15.4[a]	20.3[a]	9.5[a]	8.5[a,b]	5.1[a]	6.8[a,b]
CZE	24.4[a,b]	23.7[a]	17.5[a,b]	19.3[a]	10.7[a,b]	7.3[a,b]	5.0[a]	5.9[a,b]
GRC	48.9[c]	44.8[b]	38.1[c]	39.9[b]	23.9[c]	18.6[c]	13.6[b]	14.3[c]
HUN	25.1[a,d]	28.2[a,c]	18.9[a,b,d]	23.9[a,c]	14.2[a,b,d,e]	10.3[a,b,d]	6.7[a,c]	8.2[a,b,c]
IRL	25.7[a,d]	30.0[a,c,d]	15.7[a,b]	24.9[a,c]	8.6[a,b]	6.9[a,b]	4.1[a]	4.7[a]
LVA	24.5[a,e]	22.2[a]	15.9[a,b]	17.8[a]	10.8[a,b]	7.5[a,b]	5.2[a]	5.3[a]
LTU	24.4[a,e]	21.0[a]	16.0[a,b]	17.7[a]	9.5[a,b]	7.1[a]	5.0[a]	5.6[a]
PRT	31.5[b,d,e]	36.2[b,c,d]	22.7[b,d]	30.5[c,d]	14.2[a,b,c,d,e]	12.2[a,b,c,d]	7.9[a,c]	9.6[a,b,c]
SVN	29.6[b,d,e]	24.8[a]	21.1[b,d]	21.2[a]	13.5[b,e]	9.4[a,b]	7.1[a,c]	6.7[a,b]
ESP	44.6[c]	40.4[b,d]	33.5[c,e]	36.6[b,d]	21.0[c,d]	14.7[c,d]	11.5[b,c]	10.5[b,c]
MKD	34.0[d]	27.4[a]	26.2[d,e]	22.9[a,c]	18.2[d,e]	12.1[b,d]	10.9[c]	9.6[a,b,c]
8-year-olds°°	‡	‡	‡	‡	‡	‡	‡	‡
BEL	21.9[a]	22.4[a]	14.2[a]	17.8[a]	7.9[a]	6.7[a]	3.6[a]	4.6[a]
ITA	44.8[b]	40.4[b]	33.9[b]	34.4[b]	22.8[b]	16.0[b]	11.6[b]	11.3[b]
NOR	29.2[c]	26.2[a]	18.6[c]	21.5[c]	11.6[c]	6.2[a]	4.9[a]	3.5[a]
SVN	36.1[d]	32.0[c]	26.5[d]	26.6[d]	17.6[d]	11.9[b,c]	8.5[c]	8.5[c]
ESP	45.3[b]	41.0[b]	33.0[b]	34.4[b]	20.0[b,d]	14.7[c]	8.3[c]	9.2[b,c]
9-year-olds°°°	‡	‡	‡	‡	‡	‡	‡	‡
BEL	27.3[a]	26.6[a]	18.7[a]	21.8[a]	11.2[a]	9.0[a]	5.1[a]	5.9[a]
GRC	57.2[b]	50.0[b]	45.1[b]	42.3[b]	30.5[b]	20.8[b]	14.7[b]	14.6[b]
IRL	32.2[a,c]	30.3[a,c]	19.7[a,c]	23.1[a,c,d]	10.3[a]	6.8[a,c]	4.5[a,c]	4.8[a,c]
ITA	43.8[d]	37.4[c,d]	32.9[d]	31.4[e]	21.9[c]	13.0[d]	10.1[d]	8.4[d]
LTU	27.3[a]	21.3[e]	17.8[a]	16.9[c]	11.3[a]	5.9[c]	4.7[a]	4.1[a]
SVN	36.8[c]	33.6[c,d]	25.7[c]	29.1[d,e]	17.0[d]	13.6[d]	8.0[a,c,d]	9.8[b,c,d]
ESP	48.9[d]	42.2[b,d]	34.1[d]	35.4[b,e]	22.3[c,d]	14.6[d]	9.5[c,d]	10.0[b,d]

Abbreviations: BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IOTF, International Obesity Task Force; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a,b,c,d,e] Within each sex-age group (e.g. 6-year-old boys), proportions that share the same superscript letter do not statistically significantly differ from each other (Marascuilo procedure). For example, for the 6-year-old boys

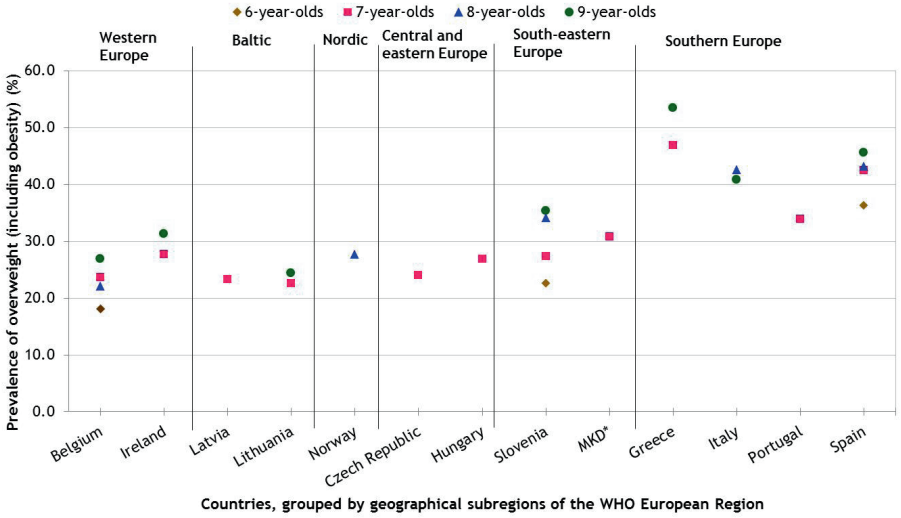
Table 3.4 *(Contd.)*
and girls, each overweight or obesity prevalence estimate is significantly different from the other two; * Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[17]. Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively; † Prevalence estimates were based on the IOTF recommended growth reference for school-age children and adolescents[19]. Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded (based on the 2007 WHO growth reference[17]). Overweight and obesity were defined by using cut-off points for BMI, passing through 25 kg/m^2 and 30 kg/m^2 by the age of 18 years, respectively; ‡ Statistically significant difference of proportions across countries for the indicated age group (chi-squared test; $P < 0.001$); ° Statistically significant difference of proportions between boys and girls for overweight (based on IOTF definition only) and for obesity (based on WHO and IOTF definitions) (chi-squared test; $P < 0.001$); °° Statistically significant difference of proportions between boys and girls for overweight and obesity (based on WHO and IOTF definitions) (chi-squared test; $P < 0.05$); °°° Statistically significant difference of proportions between boys and girls for overweight (based on WHO and IOTF definitions) and for obesity (based on WHO definitions only) (chi-squared test; $P < 0.05$).

A north–south gradient was also observed in COSI Round 1[5] as well as in other European-wide studies carried out among adolescents in 2010[23,24].

Possible explanations for the apparent north–south gradient remain unclear. Studies carried out in European children[25] and adolescents[26] suggest that shortness (low H/A) might be one of the explanations. The mean H/A Z-score values found in Italy, Portugal and Spain (but not those in Greece) were indeed significantly lower (but still higher than the growth reference values) than the values of almost all other countries. Other suggested explanations concern, among others, birth weight[27,28], sleep duration[29], dietary[23] or physical activity patterns[23], which seem to vary among children by country or subregion in Europe as well. To what extent these variables can explain the overweight north–south gradient found in COSI surveys would need to be explored further. Information was collected by some COSI countries and will be published elsewhere.

Stunting, thinness and underweight were rare among the 6–9-year-olds in any of the COSI countries. It is, however, uncertain whether these results found in the COSI countries can be generalized to the entire WHO European Region because no comparable studies in other countries could be found that collected data on these indicators for the same age range in 2009 or later. But studies done among younger children (0–5-year-olds) showed that stunting is considerable in some countries in the WHO European Region (Armenia, 19.3% overall and 36.5% in Syunik[30]; Bosnia and Herzegovina, 8.9% overall and 9.9% in the Federation of Bosnia and Herzegovina[31]; Kazakhstan, 13.1% overall and 36.2% in Aktobe Oblast[32]; Serbia, 6.6% overall and 8.3% in Belgrade[33]; and the former Yugoslav Republic of Macedonia, 4.9% overall and 13.3% in southwest region[34] (based on measured weight and height and the 2006 WHO child growth standards[35])).

(a)



(b)

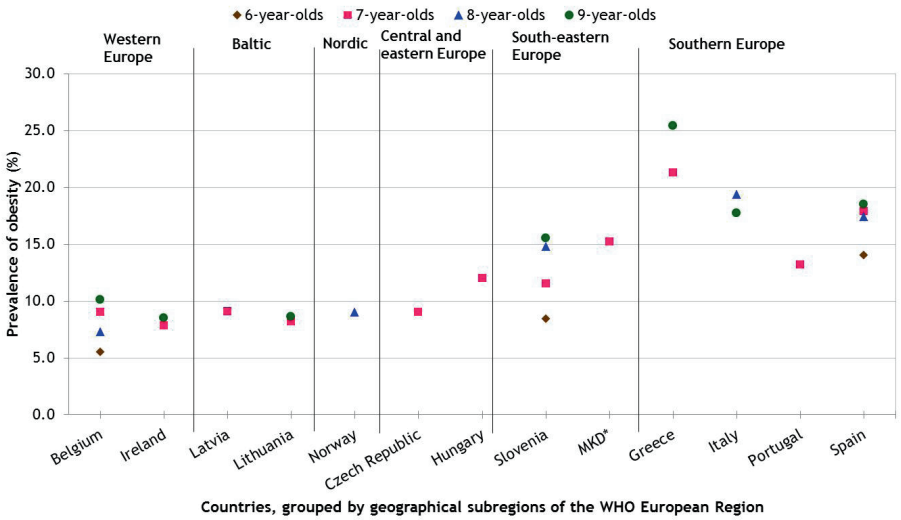


Figure 3.1 Geographical distribution of the prevalence of overweight (including obesity) (a) and obesity (b) in children aged 6–9 years (sexes combined) of COSI Round 2 (2009/2010), based on WHO definitions†

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; ISO, International Organization for Standardization; MKD, The former Yugoslav Republic of Macedonia; WHO, World Health Organization.

* MKD is the ISO 3166-1 alpha-3 country code for the former Yugoslav Republic of Macedonia; † Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[17]. Children with a body mass index-for-age Z-score < –5 or > +5 were excluded. Belgium represents Flanders only and Portugal represents all regions except Madeira. WHO European Member States are grouped into eight geographic subregions to facilitate comparative analysis and interpretation. None of the central Asian republics or the Commonwealth of Independent States participated in Round 2, and thus these two subregions are excluded from both figures.

Table 3.5 Absolute change in mean values of weight, height and BMI of boys and girls aged 6–9 years from COSI Round 1 (2007/2008) to COSI Round 2 (2009/2010), by age and country

Age group and country	Weight* (*kg*)		Height† (*cm*)		BMI‡ (*kg/m²*)	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
6-year-olds§	*NS*	*NS*	*P* < 0.01	*P* < 0.0001	*P* < 0.05	*P* < 0.01
BEL	– 0.2°°°°	– 0.1°°°°	– 0.2°°°	– 0.2°°°°	– 0.1°°°°	0
SVN	– 0.1	– 0.2	+ 0.4°	+ 0.6°°	– 0.2°°	– 0.3°°°
7-year-olds§	*P* < 0.05	*P* < 0.01	*P* < 0.001	*P* = 0.0001	*P* < 0.01	*P* < 0.05
BEL	– 0.1	– 0.4°°°°	– 0.3°°	– 0.6°°°°	0	– 0.1
CZE	+ 0.2	+ 0.4	– 0.2	– 0.2	+ 0.1	+ 0.3
IRL	– 0.7°°	– 0.9°°	– 1.0°°°	– 1.0°°°	– 0.2	– 0.3°
LVA	+ 0.2	+ 0.2	+ 0.2	– 0.1	0	+ 0.1
LTU	0	0	+ 0.3	0	– 0.1	0
PRT	– 0.4	+ 0.1	+ 0.5	+ 0.4	– 0.4°°	0
SVN	– 0.4°	– 0.3	0	0	– 0.2°°	– 0.2°
8-year-olds§	*P* < 0.0001	*P* < 0.05	*NS*	*P* < 0.05	*P* < 0.0001	*P* < 0.05
BEL	– 0.1°	– 0.1°	– 0.1°	– 0.1°	0	0
ITA	– 0.6°°°°	– 0.1	+ 0.1	+ 0.3°	– 0.4°°°°	– 0.1
NOR	+ 0.6°°	+ 0.4	– 0.1	0	+ 0.3°°°	+ 0.2°
SVN	+ 0.3	+ 0.3	+ 0.3	+ 0.2	+ 0.1	+ 0.1
9-year-olds§	*NS*	*NS*	*P* < 0.05	*P* < 0.05	*P* < 0.01	*NS*
BEL	– 0.3°°	– 0.4°°°	– 0.4°°°°	– 0.4°°°	0	– 0.1°°
ITA	– 0.5°	– 0.5°	+ 0.1	+ 0.1	– 0.3°°	– 0.3°°

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; H/A, height-for-age; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; NOR, Norway; NS, not significant; PRT, Portugal (all regions except Madeira); SVN, Slovenia; W/A, weight-for-age.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Body weight was adjusted for clothes worn when measured and children with a W/A Z-score < –6 or > +5 were excluded; † Children with a H/A Z-score < –6 or > +6 were excluded; ‡ Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded; § Significance level of the two-way ANOVA to assess the interaction effect of country and round on the change in mean values for the indicated age-sex group; ° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P < 0.05$); °° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P < 0.01$); °°° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P \leq 0.001$); °°°° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P \leq 0.0001$).

Table 3.6 Absolute change in mean values of weight-for-age, height-for-age and BMI-for-age Z-scores of boys and girls aged 6–9 years from COSI Round 1 (2007/2008) to COSI Round 2 (2009/2010), by age and country

Age group and country	W/A Z-score*		H/A Z-score†		BMI/A Z-score‡	
	Boys	Girls	Boys	Girls	Boys	Girls
6-year-olds§	*NS*	*NS*	*NS*	$P < 0.01$	$P < 0.05$	$P < 0.01$
BEL	– 0.02°	– 0.01	+ 0.01	0	– 0.04°°°°	– 0.02°
SVN	– 0.06	– 0.05	+ 0.05	+ 0.10°°	– 0.14°°	– 0.13°°°
7-year-olds§	*NS*	*NS*	*NS*	*NS*	$P < 0.001$	$P < 0.05$
BEL	+ 0.02	– 0.02	+ 0.03	– 0.01	0	– 0.03
CZE	+ 0.06	+ 0.09	– 0.02	0	+ 0.09	+ 0.14°
IRL	– 0.03	– 0.04	+ 0.01	+ 0.03	– 0.05	– 0.07
LVA	+ 0.02	0	+ 0.03	– 0.05	– 0.01	+ 0.02
LTU	+ 0.02	– 0.01	+ 0.07°	0	– 0.05	– 0.02
PRT	– 0.09	+ 0.02	+ 0.10°	+ 0.05	– 0.21°°°	– 0.01
SVN	– 0.09°°	– 0.07°	0	+ 0.01	– 0.14°°°	– 0.10°°
8-year-olds§	$P = 0.0001$	*NS*	*NS*	*NS*	$P < 0.0001$	$P < 0.05$
BEL	– 0.01	0	0	+ 0.01	– 0.02	– 0.01
ITA	– 0.11°°°	– 0.02	+ 0.02	+ 0.05°	– 0.16°°°°	– 0.05°
NOR	+ 0.10°	+ 0.08	– 0.03	0	+ 0.14°°	+ 0.11°°
SVN	+ 0.01	– 0.01	– 0.01	– 0.04	+ 0.01	0
9-year-olds§	$P < 0.05$	*NS*	*NS*	*NS*	$P < 0.01$	*NS*
BEL	0	– 0.01	0	+ 0.03°	– 0.01	– 0.03
ITA	– 0.09°	– 0.06	+ 0.02	+ 0.03	– 0.13°°°	– 0.09°

Abbreviations: ANOVA, analysis of variance; BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; H/A, height-for-age; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; NOR, Norway; NS, not significant; PRT, Portugal (all regions except Madeira); SVN, Slovenia; W/A, weight-for-age.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Body weight was adjusted for clothes worn when measured and children with a W/A Z-score < –6 or > +5 were excluded; † Children with a H/A Z-score < –6 or > +6 were excluded; ‡ Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded; § Significance level of the two-way ANOVA to assess the interaction effect of country and round on the change in mean values for the indicated age-sex group; ° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P < 0.05$); °° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P < 0.01$); °°° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P \leq 0.001$); °°°° Statistically significant difference of mean values between the two rounds for the indicated age-sex group (unpaired t-test (equal variance) or unpaired Welch's t-test (unequal variance); $P < 0.0001$).

Table 3.7 Absolute change in prevalence of overweight (including obesity) and obesity in boys and girls aged 6–9 years from COSI Round 1 (2007/2008) to COSI Round 2 (2009/2010), by age and country

Age group and country	Overweight (including obesity)* (%)		Obesity* (%)	
	Boys	Girls	Boys	Girls
6-year-olds				
BEL	– 1.3°°°	– 0.2	– 0.2	+ 0.1
SVN	– 4.6°°	– 1.9	– 1.6	– 1.6
7-year-olds				
BEL	– 0.4	– 0.1	+ 0.4	+ 0.5
CZE	+ 2.9	+ 3.5	+ 1.0	+ 1.5
IRL	– 1.9	– 1.0	– 0.1	– 2.9
LVA	+ 0.4	+ 3.2°	+ 2.1°	+ 2.9°°°
LTU	– 0.4	0	+ 0.1	– 0.1
PRT	– 9.0°°°°	+ 0.7	– 2.5	– 0.4
SVN	– 3.0°	– 3.2°	– 2.1°	– 0.4
8-year-olds				
BEL	– 0.2	– 0.3	– 0.1	+ 0.4
ITA	– 4.2°°°°	– 2.2°	– 3.9°°°°	– 1.3
NOR	+ 6.2°°°	+ 3.1	+ 4.2°°°	+ 0.2
SVN	+ 0.2	+ 0.3	+ 1.3	+ 1.0
9-year-olds				
BEL	– 0.1	– 0.6	+ 0.4	+ 0.1
ITA	– 3.3°	– 2.7	– 3.8°°	– 2.8°°

Abbreviations: BEL, Belgium (Flanders); BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia; WHO, World Health Organization.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[17]. Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively; ° Statistically significant difference of proportions between the two rounds for the indicated age-sex group (z test; $P < 0.05$); °° Statistically significant difference of proportions between the two rounds for the indicated age-sex group (z test; $P < 0.01$); °°° Statistically significant difference of proportions between the two rounds for the indicated age-sex group (z test; $P < 0.001$); °°°° Statistically significant difference of proportions between the two rounds for the indicated age-sex group (z test; $P \leq 0.0001$).

Changes from COSI Round 1 (2007/2008) to COSI Round 2 (2009/2010)

In two years, the change within country in mean weight varied from a decrease of –0.9 kg to an increase of +0.6 kg and the change in mean height varied from a decrease of –1.0 cm to an increase of +0.6 cm (Table 3.5). The observed range of the country weight and height differences is nevertheless plausible. No statistically significant variation in the change in mean W/A Z-score and H/A Z-score values was found across the countries in most age groups

(Table 3.6), which suggest the presence of the same weight and height (adjusted for age) developments in the COSI countries. This was not the case for BMI.

The absolute change in mean BMI ranged from a statistically significant decrease of –0.4 kg/m^2 (Italy and Portugal) to a statistically significant increase of +0.3 kg/m^2 (Norway). There was variation in the change in mean BMI across the countries in the 6-, 7- and 8-year-old age groups and the variation remained statistically significant when BMI was adjusted for age (Table 3.6). A significant decrease of 0.10 BMI/A Z-score per year was observed in Portuguese boys. Interestingly, a statistically significant decrease was observed in southern European countries with higher absolute BMI/A Z-scores (Italy, Portugal and Slovenia) and an increase in the group of countries with lower absolute BMI/A Z-score values (Czech Republic and Norway). Countries with higher prevalence of overweight in Round 1 (e.g. Italy and Portugal)[5] showed a decrease in prevalence (but still had among the highest estimates in Round 2), and the country with lower prevalence in Round 1 (e.g. Latvia and Norway)[5] showed an increase in prevalence (but still had a lower estimate than the countries that showed the highest decrease from Round 1 to Round 2). Changes could only be assessed for nine COSI countries and the statistically significant results suggest different developments in these countries, hence, a conclusion about the overall pattern (increase or decrease) for the entire WHO European Region (53 Member States) cannot be drawn.

Strengths

COSI requires the inclusion of national samples (unless a country's political system is decentralized like, for instance, in Belgium), and the children are selected from the school population, which is presumed to be representative of the total population for the 6-, 7-, 8- and 9-year-olds.

COSI provides a unique large dataset with a total number of more than 168 000 children with valid measurements in Round 1[5] and about 220 000 children in Round 2. It is expected that the number of children will increase in each future COSI round because four new countries (Albania, Republic of Moldova, Romania and Turkey) participated in the third COSI data collection round (2012/2013) and other countries may follow by joining the fourth round during the school year 2015/2016.

The standardized weight and height measurements in a large number of countries and the application of a consistent data collection protocol enabled the use of multiple comparisons (Tables 3.1–3.4), and the repeated COSI rounds made it possible to assess the changes over time (Tables 3.5–3.7).

Limitations

Some differences in sample size achieved might have influenced the results. Seven countries in Round 2 did not obtain a final sample of children that contained more than 60% of

the approached children and fell within the targeted age group, while eight countries did not achieve the minimum final effective sample size of ≈2800 children per age group (see Supplementary Table 3.2). However, Table 3.6 showed that all difference values of BMI/A Z-score higher than 0.05 per year were already statistically significant, which suggest that the COSI data have sufficient power to detect a significant difference of 0.10 per year if it really existed (on which sample size calculation for COSI was based – see Methods section). This also means that it is almost certain that a real change of 0.10 BMI/A Z-score per year did not happen in the COSI countries where no statistically significant changes were found.

The analyses were performed unweighted, because sampling weights to adjust for the applied sampling design, oversampling and non-response rate were available for only three countries in Round 1[5] and four countries in Round 2. This was mainly due to the incomplete registration of all children in the schools and classes. We do not know the effect of the unweighted analyses on the results, but we would expect this to be limited due to the nationally representative sampling of children.

In an optimal study design, the same scales and stadiometers should be used with similar and adequate calibration procedures. For the majority of the countries, the same equipment was used throughout the country, but data comparability would have been improved if identical equipment would have been used by each country. This was not set as mandatory in the COSI protocol, largely because of cost implications. The monitoring of data quality procedures, however, was stressed throughout the measurement period.

CONCLUSIONS

The WHO COSI includes repeated data collection rounds in 2–3-year intervals in order to assess changes in weight, height and BMI as well as in overweight and obesity prevalence estimates. The results show that with the present COSI data it is possible to detect relevant changes between rounds. A period of two years, with just two rounds of data collection, is, however, inadequate to identify clear trends within countries. Hence, continuation of the surveys will be important to evaluate the currently observed changes over a longer period. These changes varied significantly across the countries and showed little decline. All countries will thus need to strengthen their efforts in order to become on track with achieving the European Charter's goal to reverse the obesity epidemic by 2015[1]. Furthermore, it seems that active implementation of policies or interventions to counteract overweight and obesity have been triggered more by the countries with higher values in Round 1 than by the countries with lower values. It could be that the latter group of countries did not see the urgency to keep their values stable and thus to introduce overweight preventive interventions targeting school-aged children for this purpose.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

TW conceptualized and drafted the manuscript and conducted all analyses; JvR made substantial contributions to the conception and drafts of the manuscript as well as interpretation of the results; AS, GS, MH, IS, HR, ÉM, AR, RH, NPF, AP, NE, LB and JB were involved in critically reviewing a draft of the manuscript and contributed with data collection and data cleaning; IP and MK contributed with data collection and data cleaning. All authors contributed to and approved the final manuscript.

DISCLAIMER

TW and JB are staff members of the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions or the stated policy of the World Health Organization.

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Supplementary Table 3.1 Sampling characteristics for each of the 13 countries that participated in COSI Round 2 (2009/2010)

Characteristics	Countries												
	BEL	CZE	GRC	HUN	IRL	ITA	LVA	LTU	NOR	PRT	SVN	ESP	MKD
Sampling design													
Inclusion of entire targeted age group	✓												
Cluster sampling design		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New sample of schools	NA	✓*	✓	✓		✓	✓				✓	✓	✓
Same schools as selected in COSI Round 1	NA				✓			✓	✓	✓			
Schools (PSU)													
Total approached (*n*)	NA	85*	150	164	192	NA	174	164	131[†]	185	167	163	115
Total included (*n*)	NA	67*	123	98	154	NA	169	162	125[†]	172	167	144	100
Participation rate (%)	NA	78.8	82.0	59.8	80.2	NA	97.1	98.8	95.4	93.0	100	88.3	87.0
Classes (SSU)													
Total approached (*n*)	NA	NA	337	346	328	2437[‡]	279	604	131[§]	372	950	594	221
Total included (*n*)	NA	NA	265	167	260	2437[‡]	267	604	125[§]	318	950	594	210
Participation rate (%)	NA	NA	78.6	48.3	79.3	100	95.7	100	95.4	85.5	100	100	95.0

Abbreviations: ✓, applicable; BEL, Belgium (Flanders); COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NA, not applicable; NOR, Norway; PRT, Portugal (all regions except Madeira); PSU, primary sampling unit; SSU, secondary sampling unit; SVN, Slovenia.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Paediatric clinics formed the PSU and number of paediatric clinics, instead of number of schools, is given; [†] Counties formed the PSU; [‡] Classes formed the PSU; [§] Schools formed the SSU.

Supplementary Table 3.2 Number of children targeted, measured and included in the final dataset for each of the 13 countries that participated in COSI Round 2 (2009/2010)

	Countries												
	BEL	**CZE**	**GRC**	**HUN**	**IRL**	**ITA**	**LVA**	**LTU**	**NOR**	**PRT**	**SVN**	**ESP**	**MKD**
Total number of children sampled, and													
Invited to participate (*n*)	267 087	2595	7432	ND	6293	46 734	5221	12 021	3647	4725	19 431	12 886	2940
Measured (%)	99.8	94.1*	76.5	ND	64.0	91.0	82.1	81.5	87.3	79.1	82.2	59.4	96.7
With complete information (%)	49.9	94.1*	76.5	ND	63.9	89.9	82.1	81.5	87.0	79.1	82.2	59.4	96.7
Fell within the targeted age group(s) (%)	49.9	49.0*	70.9	ND	31.6	89.2	54.4	55.9	71.9	38.4	82.0	59.4	93.3
Total number of targeted children included for this paper's analyses													
Total (*n*)	133 156	1271	5269	1235	1986	41 672	2838	6721	2621	1813	15 938	7656	2744
6-year-olds; boys/girls (*n*)	26 542/ 26 105	0	0	0	0	0	0	0	0	0	1801/ 1834	901/ 917	0
7-year-olds; boys/girls (*n*)	7804/ 6841	638/ 633	1293/ 1259	553/ 682	534/ 466	0	1381/ 1457	1648/ 1794	0	910/ 903	2759/ 2493	1106/ 1101	1429/ 1315
8-year-olds; boys/girls (*n*)	23 632/ 23 171	0	0	0	0	13 197/ 12 812	0	0	1335/ 1286	0	2690/ 2599	1083/ 1047	0
9-year-olds; boys/girls (*n*)	9805/ 9256	0	1288/ 1429	0	488/ 498	8280/ 7383	0	1659/ 1620	0	0	952/ 810	749/ 752	0

Abbreviations: BEL, Belgium (Flanders); COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; ND, not determined; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia.
Note. The country codes refer to the ISO 3166-1 Alpha-3 country codes and countries were listed in alphabetical order by their full names.
* Data collected from October 2009 to December 2009 and from January 2011 to April 2011 were not taken into account in this paper.

Supplementary Table 3.3 Implementation of the WHO European Childhood Obesity Surveillance Initiative's protocol characteristics by each of the 13 countries that participated in COSI Round 2 (2009/2010)

COSI protocol characteristics	Countries												
	BEL	CZE	GRC	HUN	IRL	ITA	LVA	LTU	NOR	PRT	SVN	ESP	MKD
COSI surveillance system													
Integration with routine measurements	✓	✓		✓							✓		
Newly established surveillance system			✓		✓	✓	✓	✓	✓	✓		✓	✓
Data collection period													
Starting (*month/year*)	09/09	01/10*	11/10	04/10	10/10	04/10	03/10	02/10	09/10	04/10	04/10	10/10	10/10
Ending (*month/year*)	08/10	12/10*	03/11	06/10	11/10	10/10	04/10	05/10	12/10	12/10	04/10	05/11	12/10
Informed parental consent approach													
Passive	NA†					✓	✓						
Active	NA†	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Field examiners													
External health professionals linked to the school		✓		✓		✓			✓				
Physical education teachers											✓		
Nationally or regionally based examiners	✓		✓		✓		✓	✓		✓		✓	✓

Abbreviations: ✓, applicable; BEL, Belgium (Flanders); COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NA, not applicable; NOR, Norway; PRT, Portugal (all regions except Madeira); SVN, Slovenia.

Note. The country codes refer to the ISO 3166-1 Alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Data collected from October 2009 to December 2009 and from January 2011 to April 2011 were not taken into account in this paper; † In Flanders (Belgium), measurements of body weight and body height in schoolchildren are part of the preventive medical examinations, which are carried out within the school system and are mandatory by law.

Supplementary Text 3.4 Ethics approval procedures for participation in the WHO European Childhood Obesity Surveillance Initiative applied by each of the 13 countries that participated in COSI Rounds 1 (2007/2008) and 2 (2009/2010)

Belgium

Belgium participated in COSI Rounds 1 and 2. In both COSI rounds, ethical approval prior to data collection (weight and height measurements) were not required as the mandatory health check of children aged 3 to 18 years is regulated by law. The Centres for Pupils Counselling ('Centra voor Leerlingenbegeleiding') performed the registration, which included the measurement of height, weight, vision, position of the eyes, depth perception, colour vision and pubertal development for boys and girls. Thereafter the Flemish Agency for Care and Health received the data according to Belgian decree.

Czech Republic

The Czech Republic participated in COSI Rounds 1 and 2. The study was agreed by the Institutional Ethical Committee of the Institute of Endocrinology in Prague after having received the detailed design of the study in 2008. The study protocol was agreed for COSI rounds in 2007/2008, 2009/2010 and any following rounds. The approval letter is archived in the Ethical Committee of the Institute of Endocrinology. Paediatricians who perform the obligatory 7-year preventive check-up at paediatric clinics informed parents about the study and the measuring procedures, and gave them an informed consent form to sign before their child was measured for the study. Children were also asked to express their agreement to participate in the study before being included.

Greece

Greece participated in COSI Round 2. The survey protocol was submitted by the COSI principal investigator of Greece to the Ethics Committee of the Alexander Technological Educational Institute of Thessaloniki, the institute that is responsible for the implementation of COSI in Greece. After having studied the protocol in detail, the Ethics Committee gave its approval. The members of the Ethics Committee were: Professor Thomais Karagiozoglou, Professor Menelaos Zafrakas and Professor Vassilis Bambidis, all affiliated with the Alexander Technological Educational Institute of Thessaloniki.

Hungary

Hungary participated in COSI Round 2. Ethical permission for the 'Hungarian Childhood Study' in 2010 was granted by the Scientific and Research Ethics Committee of the Medical Research Council (approval reference number 22-272/2007-1018EKU). The entire ethics approval procedure is regulated by Act CLIV of 1997 on Health Affairs. The approval included

the purpose of the survey, the study and sampling design, the implementation in schools, the measurement protocol, the procedures for training examiners, project timetable, data management and ethical considerations as well as the information letter that was given to the parents, the written consent form and the questionnaires.

Ireland

Ireland participated in COSI Rounds 1 and 2. The 'Surveillance of obesity in Irish school children' study received ethical approval from the University College Dublin (Dublin, Ireland) Research Ethics Committee in 2008 and 2010. The approval included selection and recruitment of children through primary schools, the measurement procedures, obtaining written consent from parents and verbal consent from children, and the text in the information sheet and the consent form to the parents.

Italy

Italy participated in COSI Rounds 1 and 2. The Institutional Ethical Committee of the Italian National Institute of Health reviewed and approved the protocol of both rounds, including the use of opt-out consent, that is, parents could refuse participation in the study by specifically declining consent, and the lack of a returned form was taken to imply consent for their child's participation.

Latvia

Latvia participated in COSI Rounds 1 and 2. Ethics approval was sought for both rounds from the Central Medical Ethics Committee, which is affiliated with the Ministry of Health. The information that was required by the Ethics Committee as part of the ethics approval procedure included: the names of the researchers and their curricula vitae, study objectives, a description of the protocol, methods and technologies, expected results, ethical considerations, financing, information on the study subjects (children and parents), the informed consent form, confidentiality, etc.

Lithuania

Lithuania participated in COSI Rounds 1 and 2. Ethics approval for the 'Growth surveillance study of Lithuanian children' was sought in January 2008 (Round 1) from the Lithuanian Bioethics Committee. Permission was granted in March 2008. The documents that needed to be sent to the Committee as part of the ethics approval procedures were: the application requesting permission to perform the biomedical survey, a filled out application form for biomedical research, the study protocol, questionnaires and information on the confidentiality of personal information, a filled out ethical evaluation form for biomedical research, the curriculum vitae of the applicant and the applicant's criminal history. An extension of the

duration of the study was requested in 2010 and granted by the Lithuanian Bioethics Committee. In addition, approval to implement the study in schools was sought from the Lithuanian Ministry of Education and Science and the education departments in local municipalities in both rounds.

Norway

Norway participated in COSI Rounds 1 and 2. Ethics approval for 'The Norwegian Childhood Study' was sought for both rounds from the Regional Committee for Medical and Health Research Ethics in 2008 and 2010. The approval included permission to implement the study in schools, the measurement procedures, the information that was provided to the parents and the written consent form. The reference number for the ethics approval is S-08181a and the contact person is Professor Jørgen Hardang.

Portugal

Portugal participated in COSI Rounds 1 and 2. The Directorate-General of Health in Lisbon sought ethics approval in both rounds from the Portuguese Data Protection Authority. All methodological aspects, particularly the anthropometric measurements of the children and a precise explanation of the informed parental consent and children´s consent on the day of the measurements, were included in the application. The approval letter was sent to the Directorate-General of Health and archived there.

Slovenia

Slovenia participated in COSI Rounds 1 and 2. Data on body weight, height, gender and age were collected within the SLOFit monitoring system, which involves the assessment of growth and motor development in schoolchildren. The SLOFit system has been part of the compulsory school programme in all Slovenian schools for the last 32 years. Ethics approval was not required because data gathering, based on positive written consent of the parents, is regulated within school legislation. This legislation prescribes that the gathered data can be used for research purposes in an anonymized form without ethics approval.

Spain

Spain participated in COSI Round 2. Ethics approval from a local ethics committee was not required. Instead, the implementation of the study and access to the schools were regulated and approved by the National Health Authority and the Regional Health Authorities.

The former Yugoslav Republic of Macedonia

The former Yugoslav Republic of Macedonia participated in COSI Round 2. Ethics approval from a local ethics committee was not sought. The COSI measurements were done within

the framework of the National Annual Program of Public Health, which is annually adopted and funded by the Government of the former Yugoslav Republic of Macedonia. The Institute for Public Health of the Republic of Macedonia and Centers of Public Health are obliged to perform the measurements annually according to this Program with the objective to obtain data on the nutritional status of children. The measurements were done in public schools, which are owned by the Government.

Supplementary Table 3.5 BMI cut-off values for overweight and obesity for children aged 6–9 years, by sex and age, according to WHO and IOTF definitions

Age	Overweight				Obesity			
years : months	Boys		Girls		Boys		Girls	
	WHO*	IOTF†	WHO*	IOTF†	WHO‡	IOTF§	WHO‡	IOTF§
6:0	16.76	17.52	17.01	17.33	18.52	19.76	19.22	19.61
6:1	16.78	17.54	17.03	17.35	18.55	19.82	19.26	19.67
6:2	16.80	17.56	17.05	17.37	18.59	19.88	19.31	19.72
6:3	16.82	17.59	17.07	17.39	18.63	19.94	19.35	19.78
6:4	16.84	17.62	17.09	17.42	18.67	20.01	19.39	19.84
6:5	16.86	17.64	17.11	17.45	18.70	20.08	19.44	19.90
6:6	16.89	17.67	17.13	17.48	18.75	20.15	19.48	19.96
6:7	16.91	17.70	17.15	17.51	18.79	20.22	19.53	20.03
6:8	16.94	17.73	17.18	17.54	18.83	20.29	19.58	20.10
6:9	16.96	17.77	17.20	17.58	18.88	20.36	19.63	20.17
6:10	16.99	17.80	17.23	17.61	18.92	20.44	19.68	20.24
6:11	17.02	17.84	17.26	17.65	18.97	20.51	19.73	20.32
7:0	17.05	17.88	17.29	17.69	19.02	20.59	19.79	20.39
7:1	17.08	17.91	17.32	17.73	19.07	20.66	19.85	20.47
7:2	17.11	17.95	17.35	17.78	19.12	20.74	19.90	20.55
7:3	17.14	17.99	17.38	17.82	19.17	20.82	19.96	20.63
7:4	17.17	18.04	17.42	17.87	19.22	20.90	20.02	20.72
7:5	17.20	18.08	17.45	17.91	19.27	20.98	20.09	20.80
7:6	17.23	18.12	17.49	17.96	19.33	21.06	20.15	20.89
7:7	17.26	18.17	17.53	18.01	19.38	21.14	20.21	20.98
7:8	17.30	18.21	17.56	18.07	19.44	21.22	20.28	21.07
7:9	17.33	18.26	17.60	18.12	19.50	21.30	20.35	21.16
7:10	17.37	18.31	17.65	18.17	19.56	21.39	20.42	21.25
7:11	17.40	18.36	17.69	18.23	19.62	21.47	20.49	21.35
8:0	17.44	18.41	17.73	18.28	19.68	21.56	20.56	21.44
8:1	17.47	18.46	17.77	18.34	19.74	21.65	20.63	21.54
8:2	17.51	18.51	17.82	18.39	19.80	21.74	20.71	21.64
8:3	17.55	18.56	17.87	18.45	19.86	21.83	20.78	21.74
8:4	17.59	18.62	17.91	18.51	19.93	21.92	20.86	21.84
8:5	17.62	18.67	17.96	18.57	19.99	22.02	20.94	21.94
8:6	17.66	18.73	18.01	18.63	20.06	22.11	21.02	22.04
8:7	17.70	18.78	18.06	18.69	20.12	22.21	21.10	22.14
8:8	17.74	18.84	18.11	18.75	20.19	22.31	21.18	22.24
8:9	17.78	18.90	18.17	18.81	20.26	22.41	21.26	22.35
8:10	17.82	18.95	18.22	18.87	20.33	22.51	21.35	22.45
8:11	17.87	19.01	18.27	18.93	20.40	22.61	21.43	22.56
9:0	17.91	19.07	18.33	18.99	20.47	22.71	21.51	22.66

Supplementary Table 3.5 (*Contd.*)

Age	Overweight				Obesity			
years : months	Boys		Girls		Boys		Girls	
	WHO*	IOTF†	WHO*	IOTF†	WHO‡	IOTF§	WHO‡	IOTF§
9:1	17.95	19.13	18.38	19.05	20.54	22.82	21.60	22.77
9:2	18.00	19.19	18.44	19.12	20.61	22.92	21.68	22.88
9:3	18.04	19.25	18.49	19.18	20.69	23.03	21.77	22.99
9:4	18.09	19.31	18.55	19.24	20.76	23.13	21.86	23.09
9:5	18.13	19.37	18.61	19.31	20.84	23.24	21.94	23.20
9:6	18.18	19.43	18.67	19.38	20.92	23.34	22.03	23.31
9:7	18.23	19.49	18.73	19.44	20.99	23.45	22.12	23.42
9:8	18.28	19.55	18.79	19.51	21.07	23.55	22.21	23.53
9:9	18.33	19.61	18.85	19.58	21.15	23.66	22.30	23.64
9:10	18.38	19.67	18.91	19.64	21.23	23.76	22.39	23.75
9:11	18.43	19.74	18.97	19.71	21.32	23.86	22.48	23.86

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force; WHO, World Health Organization.
* WHO cut-off values for overweight are defined to pass through a BMI of 25 kg/m^2 at the age of 19 years[17]. Overweight is defined as a BMI greater than the given value; † IOTF cut-off values for overweight are defined to pass through a BMI of 25 kg/m^2 at the age of 18 years[19]. Overweight is defined as a BMI equal to or greater than the given value; ‡ WHO cut-off values for obesity are defined to pass through a BMI of 30 kg/m^2 at the age of 19 years[17]. Obesity is defined as a BMI greater than the given value; § IOTF cut- values for obesity are defined to pass through a BMI of 30 kg/m^2 at the age of 18 years[19]. Obesity is defined as a BMI equal to or greater than the given value.

Supplementary Table 3.6 Median and interquartile range (Q1–Q3) values of weight and BMI of boys and girls aged 6–9 years in COSI Round 2 (2009/2010), by age and country

Age group and country	Weight* (*kg*)		BMI† (*kg/m²*)	
	Boys	Girls	Boys	Girls
	Median (Q1–Q3)			
6-year-olds				
BEL	22.5 (20.6–24.8)	22.1 (20.1–24.6)	15.5 (14.7–16.5)	15.4 (14.5–16.6)
SVN	23.9 (21.7–26.9)	23.6 (21.2–26.5)	15.5 (14.5–16.8)	15.4 (14.4–16.9)
ESP	23.9 (21.8–27.1)	23.7 (21.5–26.8)	16.4 (15.4–17.7)	16.3 (15.1–18.1)
7-year-olds				
BEL	24.9 (22.5–28.1)	24.6 (22.1–28.1)	15.8 (14.8–17.1)	15.8 (14.7–17.4)
CZE	25.0 (22.7–28.0)	24.0 (21.9–28.0)	15.9 (14.7–17.1)	15.7 (14.6–17.2)
GRC	28.7 (24.9–32.6)	27.9 (24.6–32.8)	17.1 (15.7–19.3)	17.1 (15.7–19.4)
HUN	25.4 (23.0–28.9)	25.1 (22.3–29.4)	15.7 (14.8–17.3)	15.7 (14.6–17.8)
IRL	25.4 (23.1–28.2)	24.9 (22.3–27.9)	16.0 (15.2–17.2)	16.3 (15.1–17.8)
LVA	26.4 (24.0–29.7)	25.4 (22.7–28.8)	16.0 (15.0–17.2)	15.7 (14.6–17.1)
LTU	26.4 (24.3–30.1)	25.9 (23.3–29.6)	15.9 (15.0–17.2)	15.7 (14.6–17.2)
PRT	25.8 (23.3–29.4)	26.3 (23.1–30.0)	16.2 (15.1–17.9)	16.7 (15.3–18.5)
SVN	26.7 (23.9–30.2)	25.8 (23.2–29.7)	16.0 (14.9–17.6)	15.8 (14.6–17.5)
ESP	27.4 (24.4–31.6)	26.9 (23.5–31.1)	17.0 (15.6–18.9)	16.9 (15.4–19.0)
MKD	26.0 (23.1–30.5)	25.0 (22.2–29.5)	16.2 (14.9–18.2)	15.8 (14.6–17.7)
8-year-olds				
BEL	28.2 (25.6–31.7)	28.0 (25.1–31.9)	16.0 (15.1–17.4)	16.1 (15.0–17.8)
ITA	30.8 (26.9–36.3)	30.2 (26.2–35.6)	17.3 (15.8–19.9)	17.3 (15.6–19.8)
NOR	29.3 (26.2–33.1)	28.8 (25.7–32.5)	16.4 (15.3–17.9)	16.5 (15.3–18.1)
SVN	30.1 (26.7–35.0)	29.6 (26.2–34.7)	16.7 (15.4–18.9)	16.6 (15.2–18.8)
ESP	30.6 (27.0–35.7)	30.1 (26.7–35.1)	17.3 (15.9–19.6)	17.4 (15.8–19.6)
9-year-olds				
BEL	31.2 (27.9–35.9)	31.2 (27.6–36.6)	16.5 (15.3–18.4)	16.6 (15.3–18.8)
GRC	36.5 (31.9–43.9)	36.2 (30.8–43.0)	18.8 (16.9–21.8)	18.7 (16.4–21.5)
IRL	31.9 (28.3–36.2)	31.0 (27.1–36.0)	17.2 (15.9–18.7)	17.1 (15.5–19.0)
ITA	32.2 (28.1–38.2)	31.5 (27.3–37.2)	17.5 (15.9–20.2)	17.3 (15.6–19.8)
LTU	33.1 (29.7–37.8)	31.9 (28.8–37.0)	16.7 (15.5–18.5)	16.4 (15.2–18.2)
SVN	32.5 (28.6–37.6)	31.8 (28.2–37.8)	17.0 (15.7–19.2)	16.9 (15.6–19.6)
ESP	34.5 (30.5–40.3)	33.8 (29.6–39.8)	18.1 (16.4–20.5)	18.1 (16.2–20.5)

Abbreviations: BEL, Belgium (Flanders); BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; ESP, Spain; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; ITA, Italy; LTU, Lithuania; LVA, Latvia; MKD, The former Yugoslav Republic of Macedonia; NOR, Norway; PRT, Portugal (all regions except Madeira); Q1, first quartile; Q3, third quartile; SVN, Slovenia; W/A, weight-for-age.

Note. The country codes refer to the ISO 3166-1 Alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Body weight was adjusted for clothes worn when measured and children with a W/A Z-score < –6 or > +5 were excluded; † Body weight was adjusted for clothes worn when measured and children with a BMI/A Z-score < –5 or > +5 were excluded.

4

WHO European Childhood Obesity Surveillance Initiative: school nutrition environment and body mass index in primary schools

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ABSTRACT

Background: Schools are important settings for the promotion of a healthy diet and sufficient physical activity and thus overweight prevention.

Objective: To assess differences in school nutrition environment and body mass index (BMI) in primary schools between and within 12 European countries.

Methods: Data from the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) were used (1831 and 2045 schools in 2007/2008 and 2009/2010, respectively). School personnel provided information on 18 school environmental characteristics on nutrition and physical activity. A school nutrition environment score was calculated using five nutrition-related characteristics whereby higher scores correspond to higher support for a healthy school nutrition environment. Trained field workers measured children's weight and height; BMI-for-age (BMI/A) Z-scores were computed using the 2007 WHO growth reference and, for each school, the mean of the children's BMI/A Z-scores was calculated.

Results: Large between-country differences were found in the availability of food items on the premises (e.g., fresh fruit could be obtained in 12–95% of schools) and school nutrition environment scores (range: 0.30–0.93). Low-score countries (Bulgaria, Czech Republic, Greece, Hungary, Latvia, and Lithuania) graded less than three characteristics as supportive. High-score ($\geq$ 0.70) countries were Ireland, Malta, Norway, Portugal, Slovenia, and Sweden. The combined absence of cold drinks containing sugar, sweet snacks and salted snacks were more observed in high-score countries than in low-score countries. Largest within-country school nutrition environment scores were found in Bulgaria, Czech Republic, Greece, Hungary, Latvia and Lithuania. All country-level BMI/A Z-scores were positive (range: 0.20–1.02), indicating higher BMI values than the 2007 WHO growth reference. With the exception of Norway and Sweden, a country-specific association between the school nutrition environment score and the school BMI/A Z-score was not observed.

Conclusions: Some European countries have implemented more school policies that are supportive to a healthy nutrition environment than others. However, most countries with low school nutrition environment scores also host schools with supportive school environment policies, suggesting that a uniform school policy to tackle the 'unhealthy' school nutrition environment has not been implemented at the same level throughout a country and may underline the need for harmonized school policies.

INTRODUCTION

Overweight and obesity among children and adolescents remain as public health problems in the European Region of the World Health Organization (WHO). Excess body weight in childhood and adolescence is associated with a higher risk of premature death and disability in adulthood, but overweight children and adolescents are also more likely to develop noncommunicable diseases such as diabetes at a younger age[1,2]. These problems were recognized by and discussed between European Member States for the first time at the WHO European Ministerial Conference on Counteracting Obesity in 2006[3] and were given follow-up at the WHO European Ministerial Conference on Nutrition and Noncommunicable Diseases in the context of Health 2020 in 2013[4]. The European Union (EU) Action Plan on Childhood Obesity, which was launched during the Greek Presidency of the EU in February 2014, identifies children as the priority targets for action[5].

The establishment of the WHO European Childhood Obesity Surveillance Initiative (COSI) as a response to the 2006 Ministerial Conference has been the start of population-based monitoring at regular intervals of overweight and obesity among primary-school children in the Region. COSI aims to measure in a standardized way children's weight and height in order to monitor the progress in reducing overweight and to allow intercountry comparisons within this population group[6]. With the development of the COSI protocol, it was stressed that it could also be merged with other protocols to evaluate the impact of preventive interventions in school settings[7,8]. Thirteen Member States participated in the first round of measurements in school year 2007/2008 and, since then, more countries have joined this initiative.

The imbalance between energy intake and energy expenditure (including for physical activity) explains to a large extent the current overweight epidemic[2]. Individual energy intake and expenditure are affected by a wide range of environmental influences, including the obesogenic school environment[2,9–12]. School settings can be important settings to promote healthy lifestyles, in conjunction with a whole-of-society approach involving the local community and addressing health inequity. For example, schools may influence children's diets by providing school meals, participating in school fruit schemes such as those of the EU[13], controlling the availability of foods and non-alcoholic beverages and including nutrition education in the curriculum. In addition, schools can also be important settings for the promotion of physical activity, for example, through the inclusion of physical education lessons in the curriculum, better equipped play grounds, promotion of unorganized activity during breaks and the use of outdoor environments in teaching different subjects[14–20].

It would be useful if schools could be characterized in terms of their contribution to the 'obesogenic' environment so that policy-makers and schools can take this into account when they plan to implement new or strengthen existing school policies for a healthier school environment. An assessment would be key not only to improve school-based interventions

but also to monitor national policy implementation on childhood obesity. COSI also includes a school form that involves the collection of information on some school environmental characteristics related to nutrition and physical activity. It is envisaged that the information gathered by the school form on the nutrition and physical activity environment in primary schools along with the results of the mandatory height and weight measurements[6], may assist schools in developing a prevention strategy or intervention programme based on a supportive environment, with the aim of promoting healthy choices on their premises.

The intercountry analyses on body mass index (BMI) and the prevalence of overweight in both rounds suggested the presence of a north–south gradient with the highest level of overweight found in southern European countries[21,22]. In the present study, we aimed to: (1) assess regional differences within Europe and variability within a country in primary schools with respect to the availability of foods and beverages on their premises; (2) apply proxy indicators to distinguish schools in terms of their nutrition environment and in terms of BMI, by using the COSI data of two rounds (2007/2008 and 2009/2010).

METHODS

WHO European Childhood Obesity Surveillance Initiative

The first COSI data collection round took place from September 2007 to December 2008, with 13 countries participating: Belgium (Flanders), Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden. The second round was conducted from September 2009 to December 2010, with four new countries participating –Greece, Hungary, Spain and the former Yugoslav Republic of Macedonia– and two initial countries dropping out (Bulgaria and Sweden). Countries decided on the actual measurement period within the data collection rounds. Data collection, however, was avoided during the first two weeks of a school term or immediately after a major holiday[21,22].

The COSI protocol[7,8] is in accordance with the *international ethical guidelines for biomedical research involving human subjects*[23]. Depending on local circumstances, the procedures were approved by local ethical committees as well. Parents were fully informed about all study procedures, and informed consent was obtained. Children's consent was always obtained prior to the anthropometric measurements, and confidentiality of all collected and archived data was ensured[21,22]. A more detailed description of the implementation characteristics of both COSI rounds can be found elsewhere[6].

Sampling of schools and children

Nationally representative samples of children from all countries were included whereby the calculated sample size of ≈2800 children per age group was based on an 80% power to detect

a minimum difference of 0.10 Z-score in mean BMI per year at a two-sided 5% significance level and applying a design effect of 1.2. According to the first consultation in 2007 with the participating countries, an average of ≈25 pupils per class was assumed. Taking into account a consent rate of 80% and 90%, respectively, ≈124/140 classes would be required to achieve the final recommended sample size of ≈2800 pupils per targeted age group. Extra classes were required if there were fewer than 25 pupils or when there were lower attendance rates than expected[21,22].

The sample of children from Malta included all second grade classes in all 95 primary schools. The other countries applied cluster sampling using the primary school as primary sampling unit (PSU) (except the Czech Republic where the PSU was composed of paediatric clinics because COSI was attached to the mandatory health checks performed by paediatricians). Primary schools were selected randomly with probability proportional to size from the list of all primary schools, which was centrally available in each country through the Ministry of Education or at the national school registry (or, as in the Czech Republic, the national list of primary care paediatricians). If all children of the specifically targeted age group were in the same grade, then one class per school was drawn within a grade level. If the specifically targeted age group was spread across grades, however, all grades where children from this age group were present could be sampled. Countries that participated in Round 1 could decide for Round 2 either to select a new nationally representative sample of schools or to use the same schools selected in Round 1 and randomly select the classes from these sites, a 'sentinel' approach. Four countries (Ireland, Lithuania, Norway and Portugal) used this sentinel site approach. Similar schools could have been selected by chance in Round 2 by the countries that selected a new nationally representative sample of schools.

COSI targets 6-, 7-, 8- and 9-year-old children whereby countries could choose one or more of these four age groups. In Round 1, all countries except Slovenia and Sweden targeted one COSI age group, whereas in Round 2, all countries except Greece, Ireland, Lithuania and Slovenia targeted one age group. Detailed sampling characteristics have been described elsewhere[21,22]. In all countries except Hungary, all children registered in the sampled classes (regardless of whether they fell within the country's targeted age range) who had informed parental consent and who were present on the survey day were approached to be measured. In Hungary only the children in the selected classes who fell within its targeted age group (7-year-olds) were measured.

Twelve out of the 17 COSI countries administered all mandatory school questions (see below) in Round 1 or in Round 2 and were included in the present analyses: Bulgaria, Czech Republic, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Norway, Portugal (data from four schools in Madeira, collected one year after the other Portuguese regions, were not taken into account in this paper), Slovenia and Sweden. Supplementary Table **4.1** presents, for each country, the sampling characteristics of the schools and the median number of children

measured per school. In total, 1831 schools in Round 1 and 2045 schools in Round 2 returned the school form. Schools that participated in the anthropometric measurements but did not return the school form were excluded from the analyses (n = 28). Supplementary Table 4.2 gives, for each country, the data collection period of the anthropometric measurements and the period when the school form was completed.

School nutrition environment score (proxy indicator)

The COSI school form included questions on the frequency of physical education lessons (including e.g., dancing) provided to the sampled class (minutes per week), the availability of school playgrounds (yes/no), the possibility to obtain food items and beverages on the school premises (15 items were listed; yes/no), and the organisation of school initiatives to promote a healthy lifestyle (e.g., to promote physical activity and/or healthy eating) by the sampled class (yes/no). These 18 characteristics were mandatory in the COSI school form and were considered as possible modifiable opportunities in school settings by national/local governments or by schools in favour of children's healthy eating and physical activity patterns[7,8]. Moreover, they have been included in documents on the WHO framework for health promoting schools[19,20]. The school data were generally provided by the school principal, deputy headmaster or by the teachers involved with the sampled classes, except in the Czech Republic where the school form was filled in by the paediatrician or by a member of the study team together with the responsible person in the school.

Five out of the 18 characteristics under study were selected to calculate a school nutrition environment score because these items form an essential part of current policies at the European level or the national level. Two are included in current EU policies (school fruit scheme[13] and school milk programme[24]) to promote healthy eating habits and are considered supportive to a healthy school environment. Three characteristics tend to have a high content of saturated fats, free sugars or salt, are nutrient-poor and are major categories of food being advertised by the food and drink sector. They are considered unsupportive to a healthy school environment and their availability on the school premises should be limited[25]. A score of 0 or 1 was given to each answer on these five characteristics that could be obtained on the school premises: 'fresh fruit', 'milk', 'cold drinks containing sugar', 'sweet snacks' and 'salted snacks'. This grading was done according to the potential influence a school characteristic might have (to our best knowledge from literature) on the risk of excess body weight in children or its support to a healthy school environment[26–31]. An answer was graded with 1 when it was considered supportive to a healthy school nutrition environment (presence of fresh fruit and milk; absence of cold drinks containing sugar, sweet snacks and salted snacks) and with 0 when it was considered unsupportive to a healthy school nutrition environment (absence of fresh fruit and milk; presence of cold drinks containing sugar, sweet snacks and salted snacks). A school nutrition environment score was calculated for each school that

provided information on all of them by dividing the total attained supportive scores (range: 0–5) by 5. A school score of 0.0 means that all characteristics were graded as unsupportive, and a score of 1.0 means that all characteristics were graded as supportive. Three schools in Round 1 and two schools in Round 2 did not provide information on all five selected characteristics and were excluded from these analyses.

School body mass index-for-age Z-score (proxy indicator)

Taking into account the local arrangements and available budget, countries chose the most appropriate professionals to collect the children's data (e.g., physical education teachers, nationally or regionally based health professionals) and trained them. The children's body weights and heights were measured according to WHO standardized techniques[32]. Children were asked to take off their shoes and socks as well as all heavy clothing (coats, sweaters, jackets, etc.) and remove items such as wallets, mobile phones or key chains. Body weight was measured to the nearest 0.1 kg with portable digital (mainly manufacturer-calibrated) scales, and body height was measured standing upright to the nearest 0.1 cm with portable stadiometers. The average weights of types of clothing were provided by each country and were used to adjust the measured body weight for the weight of the clothes worn. BMI was calculated using the formula: adjusted weight (kg) divided by height squared (m^2). The 2007 WHO BMI-for-age (BMI/A) distributions for schoolchildren were used to compute BMI/A Z-scores[33]. The BMI/A Z-scores dataset included children for whom informed consent was given, from whom complete information on age, sex, weight and height was available and who had biologically plausible values (a BMI/A Z-score between –5 and +5)[34]. Only 169 out of 83 678 children (0.20%) fell outside the plausibility range.

A school BMI/A Z-score was calculated as the mean of the children's BMI/A Z-scores and was only calculated for those schools that had at least 15 children with complete information. The Czech Republic was excluded from this analysis because only 3% of their schools had measured more than 15 children. Three (Ireland, Lithuania and Slovenia) of the seven countries that participated in both rounds targeted an additional age group in Round 2 (9-year-olds); the data on the 9-year-olds were not used in this analysis because there were no corresponding Round 1 data to which the BMI/A Z-scores could be compared. For the comparison of the school BMI/A Z-score between the rounds, the classes that were sampled to enrol these 9-year-olds in Round 2 were deleted for this purpose.

Statistical analyses

Descriptive analyses included the calculation of percentages for the 18 school characteristics and the examination of their differences across the countries by round using chi-squared tests. If the chi-squared tests were found significant, the Marascuilo procedure[35] was used for the multi-group comparisons of proportions between countries. Schools were categorized by the number of selected nutrition-related characteristics graded as supportive (range 0–5).

For each country-specific dataset, the Shapiro-Wilk test was used to assess whether the calculated school nutrition environment scores and the school BMI/A Z-scores were normally distributed. The results of this test as well as the results of separate tests on skewness and kurtosis revealed that parametric tests could be performed. In addition, mean, standard deviation (SD) and coefficient of variation (CV) of the school scores were calculated. The one-way analysis of variance (ANOVA) test was used to assess the significant difference of mean scores across the countries in each round, followed by the Games–Howell *post hoc* test for the multiple comparisons between countries[36]. A two-way ANOVA test was applied to assess the interaction effect of country and round on the mean scores in the seven countries that participated in both rounds. In the case of significant interaction effect, the unpaired t-test was performed to assess whether the difference in mean values between the two rounds in each of the seven countries was statistically significant. Univariate linear regression analyses were performed by country to test the association of the school BMI/A Z-score with school category as well as multiple linear regression analyses by round with country as covariate.

A P value of < 0.05 was used to define statistical significance. All statistical analyses except the Games–Howell *post hoc* test were performed in Stata version 10.1 (StataCorp LP, College Station, TX, USA). The latter was performed in SPSS version 20.0 (IBM, Armonk, NY, USA).

RESULTS

School environmental characteristics on nutrition and physical activity

Eighty-six per cent of the 1831 eligible schools in Round 1 and 74% of the 2045 eligible schools in Round 2 provided information on all 18 school environmental characteristics under study, whereby all Irish, Latvian and Maltese schools in Round 1 and all Slovenian schools in Round 2 did so. The two physical activity-related characteristics and the general characteristic on school projects to promote a healthy lifestyle had the highest number of missing values (Supplementary Table 4.3).

The proportion of schools that provided the possibility to obtain food items and beverages on their premises, outside playgrounds or inside play areas, physical education lessons of ≥ 60 min per week or organized school initiatives to promote a healthy lifestyle in Round 1 is presented in Table 4.1, whereas Table 4.2 displays similar information for Round 2. There was large variation between the countries in the availability of food items or beverages. For instance fresh fruit could be obtained in 22–75% of schools in Round 1 (Table 4.1) and in 12–95% of schools in Round 2 (Table 4.2). Cold drinks containing sugar could be obtained on the premises of 40% or more of schools in five countries in Round 1 and in three countries in Round 2. Milk could be obtained in 33–95% of schools in Round 1 (Table 4.1) and in 18–96% of schools in Round 2 (Table 4.2). The highest proportion of schools that provided sweet

Table 4.1 Frequency of 18 school nutrition and physical activity environment characteristics included in the mandatory COSI school form in Round 1 (2007/2008), by country

Characteristics	Countries									
	BGR	CZE	IRL	LVA	LTU	MLT	NOR	PRT	SVN	SWE
Number of schools (*n*)	179	548	154	190	155	95	127	176	118	89
	Availability at school (%)									
Food items that can be obtained on the school premises										
1 Fresh fruit*	36.9^{a,b}	55.5^{c}	22.7^{a}	52.6^{b,c}	72.9^{d,e}	22.1^{a}	70.1^{c,d,e}	35.2^{a,b}	75.0^{†,e}	65.2^{c,d,e}
2 Vegetables*	17.9^{a,b}	48.2^{c}	3.9^{d}	40.5^{c,e}	80.7^{f}	11.6^{a,d}	48.0^{c,e}	25.6^{a,b,e}	36.4^{b,c,e}	88.8^{f}
3 100% fruit juice without sugar*	19.0^{a,b}	25.7^{a,b}	4.6^{c}	21.6^{a,b}	54.2^{d}	11.6^{a,c}	15.0^{a,c}	4.0^{c}	39.0^{b,d}	11.2^{a,c}
4 Fruit juice containing sugar*	69.3^{a}	51.6^{b}	4.6^{c,d}	48.4^{b}	63.2^{a,b}	7.4^{c,d}	0.0^{c}	5.7^{c,d}	19.5^{d}	1.1^{c}
5 Cold drinks without sugar*	33.0^{a,b}	43.3^{a}	2.6^{c,d}	36.3^{a,b}	49.0^{a}	3.2^{c,d}	0.0^{†,c}	1.1^{c}	42.4^{a,b}	20.2^{b,d}
6 Cold drinks containing sugar*	68.2^{a}	56.6^{a,b}	0.7^{c}	40.5^{b}	70.3^{a}	2.1^{c}	0.0^{†,c}	2.8^{c}	40.7^{b}	6.7^{c}
7 Hot drinks without sugar*	43.6^{a}	30.8^{a}	0.0^{b}	36.8^{a}	46.5^{a}	0.0^{b}	0.0^{†,b}	5.1^{b}	40.7^{a}	3.4^{b}
8 Hot drinks containing sugar*	57.5^{a}	55.7^{a}	0.0^{b}	42.6^{a,c}	87.1^{d}	1.1^{b}	0.0^{†,b}	3.4^{b}	28.0^{c}	5.6^{b}
9 Diet or 'light' soft drinks*	27.4^{a,b}	18.6^{a}	0.0^{c}	37.9^{b}	14.2^{a,d}	3.2^{c,d}	0.0^{†,c}	0.6^{c}	26.5^{†,a,b}	3.4^{c,d}
10 Milk*	33.5^{a}	57.7^{b}	33.1^{a}	42.1^{a,b}	42.6^{a,b}	59.0^{b,c}	95.3^{d}	77.3^{c,e}	94.9^{d}	86.5^{d,e}
11 Flavoured milk*	21.8^{a,b}	54.0^{c}	1.3^{d}	15.8^{a}	18.1^{a,b}	2.1^{d}	38.6^{b,c}	35.8^{b}	23.7^{a,b}	12.5^{†,a,d}
12 Water*	67.6^{a,b}	54.2^{a}	46.1^{a}	57.4^{a,b}	76.8^{b}	47.4^{a}	99.2^{c}	55.1^{a}	44.1^{a}	95.5^{c}
13 Yoghurt*	37.4^{a}	54.7^{b,c}	13.0^{d}	37.4^{a}	70.3^{b}	11.6^{d}	15.8^{d,e}	21.0^{a,d,e}	34.8^{a,c,e}	25.8^{a,d,e}
14 Sweet snacks*	76.5^{a}	45.6^{b}	0.7^{c}	51.1^{b,d}	69.0^{a,d}	8.4^{c}	0.0^{c}	9.1^{c}	3.4^{c}	3.4^{c}
15 Salted snacks*	73.7^{a}	18.6^{b}	0.0^{c}	14.7^{b,d}	22.6^{b}	1.1^{c}	0.0^{c}	3.4^{c,d}	9.3^{b,c,d}	2.3^{c}
Physical activity-related characteristics										
16 Availability of outside playgrounds or inside play areas where children can play during school breaks*	99.4^{†,a}	78.4^{†,b}	98.7^{a,c}	92.6^{a,c,d}	88.2^{†,b,c}	100.0^{a}	100.0^{a}	98.3^{†,a,c}	82.1^{†,b,d}	100.0^{†,a}
17 Provision of ≥ 60 min per week of physical education to pupils from participating classes*	99.4^{†,a}	97.9^{†,a,b}	92.9^{a,b}	99.5^{a}	99.3^{†,a}	83.2^{b}	92.9^{†,a,b}	90.7^{†,a,b}	100.0^{a}	76.2^{†,b}
General characteristic										
18 Any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes*	42.4^{†,a}	87.7^{†,b}	88.3^{b,c}	96.8^{c}	54.2^{†,a}	89.5^{b,c}	62.0^{†,a}	64.3^{†,a}	61.5^{†,a}	89.7^{†,b,c}

Abbreviations: BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; IRL, Ireland; ISO, International Organization for Standardization; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal; SVN, Slovenia; SWE, Sweden.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

^{a,b,c,d,e,f} Within each characteristic (i.e., by row), proportions that share the same letter superscript do not statistically significantly differ from each other (Marascuilo procedure); * Statistically significant difference of proportions across the 10 countries in COSI Round 1 (2007/2008) (chi-squared test; $P < 0.001$); † Not all schools that returned a school form provided information for this characteristic (Supplementary Table 4.3).

Table 4.2 Frequency of 18 school nutrition and physical activity environment characteristics included in the mandatory COSI school form in Round 2 (2009/2010), by country

Characteristics	Countries								
	CZE	GRC	HUN	IRL	LVA	LTU	NOR	PRT	SVN
Number of schools (*n*)	882	123	98	154	169	160	125	167	167
	Availability at school (%)								
Food items that can be obtained on the school premises									
1 Fresh fruit*	47.1^{a}	12.2^{b}	82.7^{c,d}	24.0^{b}	53.9^{a,e}	67.5^{c,e}	67.2^{c,e}	64.1^{c,e}	95.2^{d}
2 Vegetables*	39.0^{a}	4.9^{b}	23.5^{a}	4.6^{b}	44.4^{a,c}	72.5^{d}	37.6^{a,c}	27.0^{a}	56.9^{c,d}
3 100% fruit juice without sugar*	18.3^{a}	46.3^{b,c}	29.6^{a,b}	7.1^{d,e}	20.1^{a,d}	63.1^{c}	17.6^{a,d}	2.4^{e}	22.2^{a,d}
4 Fruit juice containing sugar*	30.7^{a}	32.5^{a,b}	52.0^{b,c}	4.6^{d}	47.3^{b,c}	59.4^{c}	0.0^{d}	3.6^{d}	35.9^{a,b}
5 Cold drinks without sugar*	27.7^{a}	12.2^{b,c}	28.6^{a,b}	1.3^{c,d}	34.3^{a}	42.5^{a}	0.0^{†,d}	1.8^{c,d}	28.1^{a,b}
6 Cold drinks containing sugar*	35.8^{a}	11.4^{b,c}	49.0^{a,d}	0.0^{e}	42.0^{a}	68.1^{d}	0.0^{†,e}	1.8^{b,e}	28.7^{a,c}
7 Hot drinks without sugar*	19.7^{a}	6.5^{b,c}	17.4^{a,b}	0.7^{c}	37.9^{d}	50.0^{d}	0.0^{†,c}	3.6^{b,c}	31.7^{a,d}
8 Hot drinks containing sugar*	37.6^{a}	7.3^{b}	40.8^{a}	0.0^{b}	46.8^{a}	77.5^{c}	0.0^{†,b}	4.2^{b}	48.5^{a}
9 Diet or 'light' soft drinks*	8.5^{a}	3.3^{a,b}	20.4^{a,c}	0.0^{b}	27.8^{c}	6.3^{a,b}	0.0^{†,b}	1.2^{b}	4.2^{a,b}
10 Milk*	40.9^{a}	17.9^{b}	38.8^{a,b}	35.7^{a,b}	27.2^{a,b}	39.4^{a}	95.2^{c}	95.8^{c}	91.6^{c}
11 Flavoured milk*	36.7^{a}	18.7^{b}	32.7^{a,b}	3.3^{c}	18.3^{b}	15.6^{b,c}	43.2^{a}	41.9^{a}	18.6^{b}
12 Water*	35.5^{a}	56.1^{b}	62.2^{b}	50.7^{a,b}	55.0^{b}	68.1^{b}	99.2^{c}	47.3^{a,b}	3.0^{d}
13 Yoghurt*	35.2^{a}	4.9^{b}	28.6^{a,c}	13.6^{b,c}	37.3^{a}	70.0^{d}	13.6^{b,c}	15.6^{b,c}	29.3^{a,c}
14 Sweet snacks*	26.8^{a}	17.9^{a,b}	51.0^{c}	1.3^{d}	48.5^{c}	60.0^{c}	0.0^{d}	4.8^{b,d}	4.8^{b,d}
15 Salted snacks*	12.2^{a}	13.8^{a,b}	36.7^{c}	1.3^{†,b,d}	11.2^{a,b}	20.6^{a,c}	0.0^{d}	1.2^{b,d}	0.0^{d}
Physical activity-related characteristics									
16 Availability of outside playgrounds or inside play areas where children can play during school breaks*	78.2^{†,a}	98.1^{†,b}	81.4^{†,a,c}	100.0^{†,b}	94.0^{†,b,c}	90.9^{†,b,c}	100.0^{b}	99.4^{†,b}	83.2^{a,c}
17 Provision of ≥ 60 min per week of physical education to pupils from participating classes*	98.5^{†,a,b}	95.4^{†,a,b}	100.0^{†,a}	88.2^{†,b}	98.8^{a,b}	100.0^{†,a}	95.8^{†,a,b}	91.5^{†,a,b}	100.0^{a}
General characteristic									
18 Any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes*	87.0^{†,a}	42.3^{†,b}	88.4^{†,a}	93.5^{†,a}	95.2^{a}	50.4^{†,b}	58.1^{†,b}	92.0^{†,a}	84.4^{a}

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; LTU, Lithuania; LVA, Latvia; NOR, Norway; PRT, Portugal; SVN, Slovenia.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

^{a,b,c,d,e} Within each characteristic (i.e., by row), proportions that share the same letter superscript do not statistically significantly differ from each other (Marascuilo procedure); * Statistically significant difference of proportions across the nine countries in COSI Round 2 (2009/2010) (chi-squared test; $P < 0.001$); † Not all schools that returned a school form provided information for this characteristic (Supplementary Table 4.3).

snacks on their premises was found in Bulgaria (77%), Lithuania (69%, Round 1; 60% Round 2), Hungary (51%), Latvia (51%, Round 1; 49% Round 2) and the Czech Republic (46%, Round 1; 27% Round 2). Fewer schools made salted snacks available on their premises than sweet snacks, but 37% of Hungarian schools (Round 2) and 74% of Bulgarian schools (Round 1) still provided them. Norway was the only country in both rounds that did not make cold drinks containing sugar, sweet snacks and salted snacks available to pupils on their school premises. The two physical activity-related characteristics were more uniform across the countries (ranging from 76% to 100%), while reported initiatives to promote a healthy lifestyle (with a focus on physical activity promotion and/or healthy eating) varied from 42% of schools in Bulgaria and Greece to 97% of schools in Latvia. The results of the multi-country comparisons of Round 1 and Round 2 are also presented in Table 4.1 and Table 4.2, respectively.

School nutrition environment score

The school nutrition environment scores, based on the five selected nutrition-related characteristics, are presented in Table 4.3. Based on the multiple comparisons of the mean scores across the countries, which was done for each round, it appeared that two non-overlapping clusters of countries could be determined at a score of 0.70 that were statistically significant from each other. The countries in the high-score cluster had a mean score of 0.70 or higher (letter superscripts a, c, d, e and h in Round 1) and the countries in the low-score cluster had a mean score below 0.70 (letter superscripts b, f and g in Round 1. None of the countries changed from one cluster to the other from Round 1 to Round 2. Two-way ANOVA tests showed a statistically significant interaction effect of country and round in the seven countries that participated in both rounds; hence, unpaired t-tests were performed and showed a statistically significant difference (i.e., improvement) in mean scores between the two rounds in the Czech Republic, Portugal and Slovenia.

Higher within-country variability in scores was detected for some countries, in particular in Bulgaria, Czech Republic Greece, Hungary, Latvia and Lithuania, compared with the other countries. This is clearly illustrated in Figure 4.1, which shows that both low-score and high-score schools were present in these six countries. Figure 4.1 also portrays that the median scores remained the same in all countries except Portugal and Slovenia in both rounds.

Table 4.3 School nutrition environment score characteristics of the schools that provided information on all five* selected characteristics in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by sampling approach and country

Countries	Number of schools (*n*)		School nutrition environment score Mean ± SD (CV (%))	
	Round 1	Round 2	Round 1†	Round 2†
Same schools in both rounds				
Ireland	154	153	0.71 ± 0.14[a] (20.2)	0.71 ± 0.16[a] (22.2)
Lithuania	155	160	0.51 ± 0.23[b] (45.2)	0.52 ± 0.25[b] (48.5)
Norway	126	124	0.93 ± 0.11[c] (11.3)	0.92 ± 0.10[c] (11.2)
Portugal‡	176	167	0.79 ± 0.14[d,e] (17.7)	0.90 ± 0.13[c] (14.3)
New sample of schools in both rounds				
Bulgaria	179	–	0.30 ± 0.24[f] (79.3)	–
Czech Republic‡	548	882	0.58 ± 0.21[g] (35.5)	0.63 ± 0.17[d] (26.6)
Greece	–	123	–	0.57 ± 0.18[b,d] (31.2)
Hungary	–	98	–	0.57 ± 0.28[b,d] (49.3)
Latvia	190	169	0.58 ± 0.19[b,g] (32.8)	0.56 ± 0.19[b] (33.8)
Malta	95	–	0.74 ± 0.14[a,d] (18.5)	–
Slovenia‡	116	167	0.83 ± 0.14[e,h] (16.7)	0.91 ± 0.11[c] (12.5)
Sweden	89	–	0.88 ± 0.15[c,h] (16.7)	–

Abbreviations: –, no participation; ANOVA, analysis of variance; COSI, Childhood Obesity Surveillance Initiative; CV, coefficient of variation; SD, standard deviation.

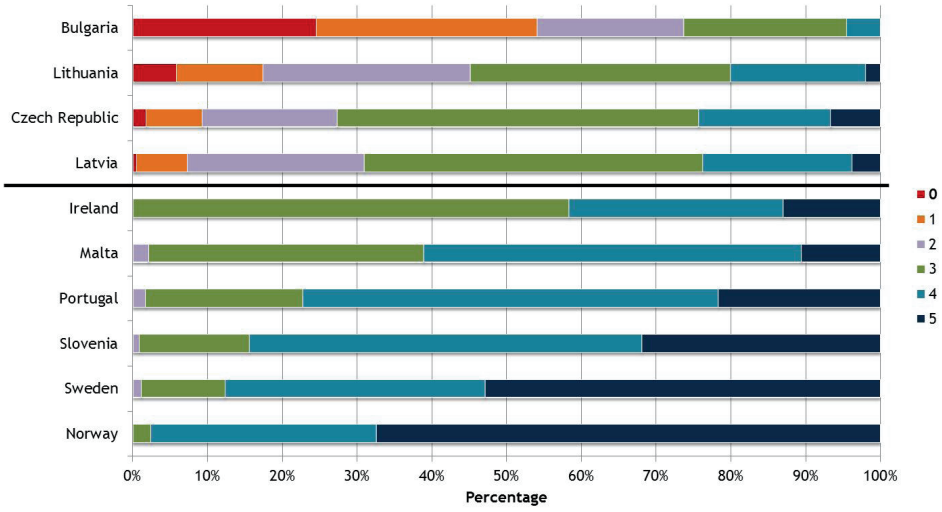
[a,b,c,d,e,f,g,h] Within each round (i.e., by column), scores that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test); * The five selected nutrition-related school environmental characteristics were: fresh fruit, milk, cold drinks containing sugar, sweet snacks or salted snacks can be obtained on the school premises; † Statistically significant difference of mean scores across countries for the indicated round (one-way ANOVA; $P < 0.0001$); ‡ Statistically significant difference of mean scores between the two rounds for the indicated country (unpaired t-test; $P < 0.0001$).

School body mass index-for-age Z-score

The choice for a minimum of 15 children with valid measurements resulted in an exclusion rate of 61% of the schools in Hungary. Lower but still substantial exclusion rates were found in Latvia (47%), Ireland (45%), Norway (39%) and Portugal (34%). The exclusion rates of schools in the other countries ranged from 1% to 22%.

Table 4.4 presents, for each country, the mean school BMI/A Z-score of the schools that measured the height and weight of at least 15 children. All mean Z-scores were positive, and the multiple comparisons show a high variability across the countries in both rounds whereby the highest scores were found in Greece, Ireland, Malta and Portugal. A large spread of scores within countries was also observed. Unpaired t-tests showed a statistically significant decrease in mean scores from the first to the second COSI round in Portugal only.

Round 1



Round 2

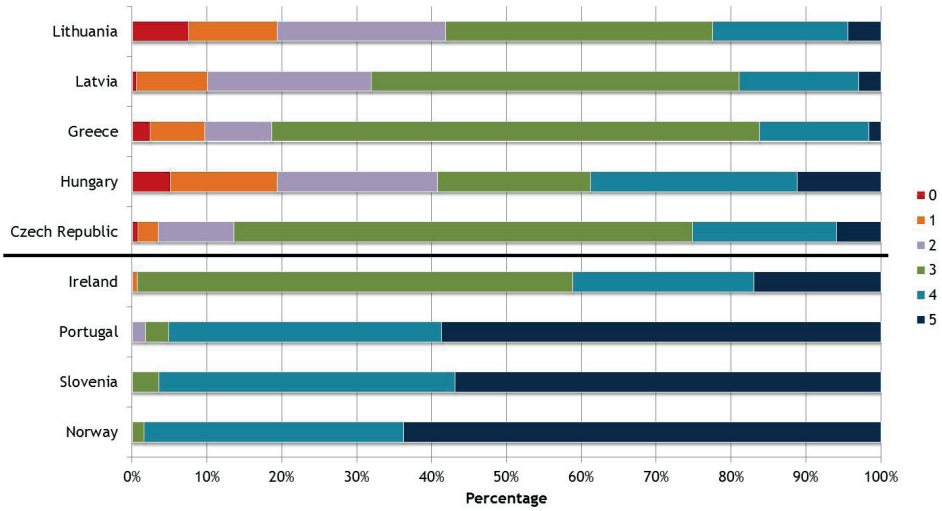


Figure 4.1 Distribution of schools in categories based on the number of characteristics graded as supportive ('five selected characteristics')* in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by country (%)†

Abbreviation: COSI, Childhood Obesity Surveillance Initiative.
Notes. The countries are ranked by score. The horizontal line distinguishes the low-score cluster (above the line; countries with a score of < 0.70) from the high-score cluster (below the line; countries with a score ≥ 0.70).
* Fresh fruit and milk can be obtained on the school premises and cold drinks containing sugar, sweet snacks or salted snacks cannot be obtained on the school premises; † Schools that provided information on all five selected nutrition-related school environmental characteristics were included.

Table 4.4 School BMI/A Z-score characteristics and linear regression analyses between school BMI/A Z-score and school category based on the number of characteristics graded as supportive* of primary schools[†] in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by sampling approach and country

Countries	Number of schools (*n*)		School BMI/A Z-score Mean ± SD (CV (%))		Linear regression with school categories α; ß (probability F-value)	
	Round 1	Round 2	Round 1[‡]	Round 2[‡]	Round 1	Round 2
Same schools in both rounds						
Ireland	98	72[¶]	0.54 ± 0.28[a,b] (52.2)	0.50 ± 0.28[a,b] (55.0)	0.46; 0.02 (0.688)	0.56; –0.01 (0.767)
Lithuania	135	136[¶]	0.25 ± 0.28[c] (111.7)	0.20 ± 0.38[c] (191.6)	0.14; 0.03 (0.140)	0.16; 0.01 (0.667)
Norway	80	72	0.32 ± 0.27[c] (84.7)	0.38 ± 0.33[a,d] (86.2)	–0.10; 0.08 (0.197)	**–0.59; 0.18 (0.015)**
Portugal[§]	113	112	0.73 ± 0.32[d] (43.7)	0.60 ± 0.34[b] (56.2)	0.99; –0.05 (0.216)	0.59; 0.00 (0.972)
New sample of schools in both rounds						
Bulgaria	140	–	0.36 ± 0.45[c,e] (123.7)	–	0.48; –0.05 (0.128)	–
Greece	–	114	–	1.02 ± 0.23[e] (22.3)	–	1.11; –0.02 (0.329)
Hungary	–	38	–	0.29 ± 0.38[a,c,d] (132.1)	–	0.24; 0.01 (0.734)
Latvia	100	92	0.23 ± 0.25[c] (109.7)	0.27 ± 0.33[c,d] (120.5)	0.22; 0.00 (0.924)	0.43; –0.05 (0.190)
Malta	74	–	0.59 ± 0.26[a] (43.4)	–	0.45; 0.03 (0.468)	–
Slovenia	116	164[¶]	0.46 ± 0.28[b,e] (60.9)	0.40 ± 0.31[a,d] (79.1)	0.70; –0.05 (0.223)	0.49; –0.02 (0.703)
Sweden	86	–	0.33 ± 0.21[c] (64.4)	–	**0.73; –0.07 (0.019)**	–
Total countries	942	800	0.42 ± 0.34 (82.2)	0.47 ± 0.41 (87.5)	**0.29; 0.02 (0.0002)[#]**	**0.44; 0.09 (< 0.0001)[#]**

Abbreviations: –, no participation; α, constant term (y-intercept); ß, regression coefficient of the school category; ANOVA, analysis of variance; BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative; CV, coefficient of variation; SD, standard deviation.

Note. Significant F-values are shown in bold.

[a,b,c,d,e] Within each round, scores that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test);* School categories were based on the number of selected nutrition-related school environmental characteristics graded as supportive and ranged from 0 to 5, whereby supportive grading was defined as: fresh fruit and milk can be obtained on the school premises and cold drinks containing sugar, sweet snacks or salted snacks cannot be obtained on the school; [†] A school that had fewer than 15 children with valid measurements was excluded; [‡] Statistically significant difference of mean scores across countries for the indicated round (one-way ANOVA; $P < 0.0001$); [§] Statistically significant difference of mean scores between the two rounds for the indicated country (unpaired t-test; $P < 0.01$); [¶] Classes that were sampled in Round 2 to enrol the newly targeted 9-year-old age group were deleted; [#] Multiple linear regression analysis was adjusted for country (coefficient for country: 0.01 in Round 1 and –0.08 in Round 2).

The country results of the linear regression analyses between the school BMI/A Z-scores and school categories that were based on the number of five nutrition-related characteristics graded as supportive are also given in Table 4.4. None of the country linear associations were statistically significant except in Sweden in Round 1 (negative) and Norway in Round 2 (positive). A statistically significant positive linear association was found for the total group of schools in both Round 1 and Round 2 (adjusted for country).

DISCUSSION

School nutrition environment

A large variability in school nutrition environment scores was found across countries whereby higher scores correspond to higher support for a healthy school nutrition environment. The low-score countries (Bulgaria, Czech Republic, Greece, Hungary, Latvia and Lithuania) graded on average less than three characteristics as supportive, and the high-score countries (Ireland, Malta, Norway, Portugal, Slovenia and Sweden) judged at least three out of the five graded characteristics supportive. We also observe a high variability in scores between schools (CV range: 11–79%) within the same country, especially in the six low-score countries, where schools could be found in each quintile of the potential range of scores (between 0 and 1). None of the countries moved between clusters within the two-year observation period.

A number of methodological issues should be mentioned. Firstly, the COSI mandatory school form was not based on validated questionnaires, however, we pilot-tested a draft version of the COSI form in some of the participating countries prior to the first data collection in school year 2007/2008. This pilot resulted in 18 mandatory environmental characteristics related to nutrition and physical activity.

Secondly, although not validated, the five selected nutrition-related characteristics were graded with the same weight (0 or 1), which is not an uncommon approach. For instance, Thomson *et al*. also did not give different weights to the yes/no responses of the 'healthy/unhealthy' foodservice offerings items[27]. Like in our approach, they coded the availability of 'healthy' offering items with a '1' and the availability of 'unhealthy' offering items with a '0', so that higher scores corresponded to higher occurrence of healthy practices. Turner and Chaloupka created a school food environment score for elementary schools by dividing the sum of 'yes' responses for 16 items (scored either 0 or 1) by the number of valid items, then multiplying by 100. Each school's score could range between 0 and 100 with higher scores indicating a healthier environment[37]. The pilot of the initial COSI school form also resulted in an additional set of school environmental characteristics related to nutrition and physical activity that could be included on a voluntary basis by the countries (for example, the availability of vending machines, school canteen or cafeteria as well as the provision of fresh

fruit, vegetables or milk for free, nutrition education or school bus transport). These optional characteristics were not included in the present analyses because they were not collected by all 12 countries. We also performed a score calculation based on 16 mandatory characteristics, which resulted in similar ranking of countries, except that Ireland would then be grouped in the low-score cluster, and Latvia and Lithuania in the high-score cluster (data not presented). The calculation of the score might have been improved by adding the optional characteristics to the mandatory part of the COSI form. This could be considered in future COSI rounds whereby it would be essential to sustain the balance between obtaining more information on a mandatory basis by all participating countries, keeping COSI as a surveillance system that is easy to implement with limited resources, and the added value of this additional information for the calculation of the school environment score.

Finally, COSI used a school-based cluster sampling approach to obtain a nationally representative sample of children, and thus we are confident that the calculated score can be considered representative for a country. Only the Czech Republic took another approach whereby the PSUs were paediatric clinics, which resulted in a higher number of schools linked to the children measured when compared to other countries.

One may speculate that the lower school nutrition environment score found in some countries is related to the absence or inadequate implementation of national policies. For instance, it is conceivable that a country had no formal national health promoting school policy at the time of the two COSI data collection rounds or that a policy existed but that it had not been fully implemented yet throughout the country. Unfortunately, not much information is available from literature. A European study done in 2013 among 43 Schools for Health in Europe member countries on the state of health promoting schools showed that 2–10% of Czech schools, 20% of Lithuanian schools, 50% of Slovenian schools and 100% of Portuguese schools could be considered as health promoting schools[38]. In addition, 16 (62%) of 26 National Coordinators that completed the questionnaire reported that their country has a formal national health promoting schools policy. Unfortunately the study reference did not list these 16 countries[38]. A Danish study suggests that organic food policies in schools may have the potential to support a healthier school food environment[39], and a study conducted in England observed considerable improvements in lunchtime food provision after the introduction of new compulsory standards for school food in 2009[40].

Scholtens *et al*.[41] suggested that school size might be a factor playing a role in the high variation in scores between schools. They conducted a nationwide study among all Dutch secondary schools about the obesogenity of the school environment. Their findings suggest that vending machines containing soft drinks and/or sweets and candy bars, and facilities on or near school premises where students could be physically active were found less often in small schools (< 500 students) than in large schools (> 1000 students)[41]. Other factors might be the influence that school management has on the food supply offered[41], the presence of

written school rules to restrict the consumption of savoury and sweet snacks[42] or school type (private vs. public)[27]. The COSI school form did not include questions on these four described factors, but they could be considered for inclusion in future rounds.

L'Abbé *et al*. have recently published a framework for assessing food environments in public sector settings whereby the school setting was used as a case study for its development[43]. We do not know whether this framework has already been used in European schools, and studies other than COSI done in Europe that described the school nutrition and physical activity environment in schools characteristics could only be identified for Belgium[42], the Netherlands[26,41,44] and Norway[45]. The five nutrition-related characteristics that have been selected to calculate a score are included in current EU policies[13,24] or have been considered in discussions to reduce the marketing of foods and non-alcoholic beverages to children[25]. Our findings suggest that the use of these five characteristics could already give a proxy indication of the level on which schools work on a healthy school nutrition environment. The combined absence of sugar-containing cold drinks, sweet snacks and salted snacks were more observed in high-score countries than in low-score countries (except in Slovenia where the availability of fresh fruit and the absence of sweet snacks and salted snacks led to a higher score). As a next step, local policy-makers should become familiar with further school details (including the voluntary COSI school form characteristics if collected by their country) before decisions can be made on which characteristics should be the target for further improvement of the healthy school nutrition environment. The involvement of the community and other local stakeholders (for instance, fruit suppliers) may be considered as well as other components that have been included in the WHO school policy framework for the implementation of the WHO Global Strategy on Diet, Physical activity and Health[15], the WHO framework for health promoting schools[18–20] and the framework developed by L'Abbé *et al*.[43].

Longitudinal studies on the school nutrition and physical activity environment are scarce. The only European study we could identify was a nationwide Dutch study among secondary schools, which was able to show, over a period of four years, changes in both supportive and unsupportive nutrition or physical activity environment characteristics[26]. In this stage of the COSI-project, we could only compare the school nutrition environment over a two-year-interval, and a statistically significantly improvement in scores was observed in three countries. The improvement seen in the Czech Republic might be due to the implementation of both national[46] and local school projects on healthy nutrition[47], whereas the improvement seen in Portugal might be due to the rollout of various school projects throughout the country (for example the 'Healthy Eating in School Health Program'[48]). The improvement in Slovenia, in particular the observed increase of the availability of fresh fruit in the schools (Tables **4.1** and **4.2**), might be related to the introduction of the school fruit and vegetables scheme during the school year 2009/2010[49].

School body mass index-for-age Z-score

A school BMI/A Z-score was calculated as the mean of the BMI/A Z-score of all children measured in that school. All country mean school values of the participating countries were positive and thus higher than the 2007 WHO growth reference[33]. A cluster of low-score countries (with a mean BMI/A Z-score value between the expected WHO reference value and 0.5 SD away from this reference median value) and a cluster of high-score countries (with a value more than 0.5 SD away from the 2007 WHO growth reference median) could be identified. Greece, Ireland, Malta and Portugal were grouped in the high-score cluster, thus in the group of countries with a high level of overweight. Over a period of two years, only Portugal showed a statistically significant decrease (i.e., improvement) in scores, but none of the countries moved from one cluster to the other.

A methodological issue to point out is our choice of a minimum number of 15 measured children that was used for the estimation of a school mean BMI/A Z-score. Of course it would have been preferable to have set this minimum number higher to further increase the precision for the calculation of the school mean value. But for a relevant further increase of the precision, the number of children had to be increased substantially, and this would have led to an unacceptably low number of eligible schools. Most countries targeted only one age group and, following the COSI protocol, thus sampled one or two classes per school[7,8]. This resulted in 50% of schools in six countries that measured about 15–20 children or fewer (Supplementary Table 4.1). With the minimum number set at 15 children, we encountered a school inclusion rate below 40% only in Hungary and a school inclusion rate of 53–99% in the other countries. Because only 3% of Czech schools met this eligibility criterion, the Czech data, unfortunately, had to be excluded from these analyses. (The PSU in the Czech Republic was not schools but paediatric clinics, and only a few children from a paediatric clinic went to the same school).

In a normal distribution, the prevalence of overweight in countries with a mean BMI/A Z-score value of zero (thus similar to the growth reference median value) would be about 15%, and in countries with a mean BMI/A Z-score value of one (the WHO cut-off value for overweight in schoolchildren[33]) 50%. All country values were higher than zero but not higher than one (range: 0.20–1.02), meaning that the prevalence of overweight in the countries would be between 15% and 50% whereby the highest prevalence was found in Greece, Ireland, Malta and Portugal. Comparing these prevalence figures (thus based on school mean values) with other overweight prevalence studies using measured weight and height and based on the sample of children[50–52], it seems that our approach can give a proxy indication of the level of overweight in a country. However, we did not find statistically significant changes between rounds (except in Portugal) using school mean values as we have seen when using mean BMI/A Z-scores based on the entire sample of individual children[22].

The existence of school policies in schools was not studied in COSI, and information on socioeconomic factors (education and occupation of the parents) was only collected by a few countries through the COSI family form[7,8]. It is thus not clear whether these two factors could have influenced the high variability found in school BMI/A Z-scores between or within countries, as has been shown (but not consistently) by other studies. For instance, a European multicentre study[53] presented a heterogeneous association between socioeconomic factors and childhood overweight across different European regions, and a systematic review[54] suggests that some school policies may have been effective in improving the food environment and dietary intake in schools; but there was little assessment of their impact on BMI.

Association between school nutrition environment and school body mass index-for-age Z-score

In our study, we used a school score approach to describe the nutrition environment and level of BMI across schools. For the individual countries we could not demonstrate an association between the school BMI/A Z-score and the school supportive level to a healthy nutrition environment, except for Norway and Sweden (Table 4.4). However, in these two high-score countries the range of scores was quite small (four or five characteristics were graded as supportive in 99% of the Norwegian schools and in 87% of the Swedish schools) and thus the regression results (different directions of association) should be interpreted with caution. Taking the school scores of all countries together, we found small but statistically significant positive associations between the school supportive level and the BMI level, indicating that at the moment of data collection the schools that were most active in creating a healthy nutrition environment were also the schools with the highest BMI/A Z-scores. Whether the nutrition policy at the schools was a consequence of the overweight and obesity level of the schools is unclear.

Several reviews have been done to assess the effectiveness of school-based interventions in reducing or preventing overweight and obesity among individual children and adolescents[55–58], and studies have been carried out to examine the association between environmental characteristics and BMI at the individual level[29,59]. We could not identify studies that used a school score approach to describe the level of overweight in schools.

It is generally known that overweight and obesity are multidimensional health problems resulting from a diverse set of factors and settings. For example, family environmental factors[60] or food outlets in the local environment[61] are potential contributors to child health and may have a stronger influence on developing excess body weight than school settings. In addition, the short time span of two years may have played a role, although a four-year longitudinal study also did not find an association between the introduction of competitive food sales in schools and children's weight gain between fifth and eighth grades[62]. Furthermore, we did not investigate the time point when a policy to restrict or promote the availability of certain

foods or beverages was introduced in a school (if it existed). Hence, we do not know whether the period between the introduction of this policy and the two COSI rounds was sufficiently long to observe an influence of a change in the school nutrition environment on the school BMI. Follow-up COSI rounds, as planned at a regular interval, may provide more conclusive answers provided that, at the same time, a time table of introduced new or modified policies is kept.

CONCLUSIONS

Some European countries have implemented more school policies that are supportive to a healthy nutrition environment than others. However, most countries with low school nutrition environment scores also host schools with supportive school environment policies, suggesting that a uniform school policy to tackle the 'unhealthy' school nutrition environment has not been implemented at the same level throughout a country and may underline the need of harmonized school policies. The proxy indicator that we have applied may trigger policy-makers in the participating COSI countries to further elaborate on the school nutrition environment in their country. The indicator, when confirmed by other similar studies, could then assist countries in improving school interventions and monitoring their national policies targeting school settings and childhood obesity. Making the healthy choices available on their premises (e.g., presence of fresh fruit and milk; absence of cold drinks containing sugar, sweet snacks and salted snacks) schools may support pupils in adopting healthy eating habits.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

TW conceptualized and drafted the manuscript and conducted all analyses; JvR made substantial contributions to the conception and drafts of the manuscript as well as interpretation of the results; AS, NE, AY, MK, GS, AR and JB were involved in critically reviewing a draft of the manuscript and contributed with data collection and data cleaning; VD, MH, ÉM, IP, AP, VFS and RH contributed with data collection and data cleaning. All authors contributed to and approved the final manuscript.

DISCLAIMER

TW and JB are staff members of the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions or the stated policy of the World Health Organization.

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Supplementary Table 4.1 School sampling characteristics and number of children measured per school in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by country

Characteristics	Countries									
	BGR		CZE		GRC		HUN		IRL	
	COSI data collection round									
	1	2	1	2*	1	2	1	2	1	2†
Targeted age groups	7	–	7	7	–	7,9	–	7	7	7,9
Schools										
Sampled (*n*)	184	–	NA§	NA§	–	150	–	164	498	192
Participated in weight and height measurements (*n*)	184	–	543§	882§	–	120	–	98	163	154
Completed a school form (*n*)	179	–	548§	882§	–	123	–	98	154	154
Children measured in a school										
Median (*n*)	19	–	1§	1§	–	41	–	12	18	24
Minimum (*n*)	2	–	1§	1§	–	1	–	1	2	2
Maximum (*n*)	43	–	29§	31§	–	169	–	34	32	60

Abbreviations: –, no participation; BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; LTU, Lithuania; LVA, Latvia; MLT, Malta; NA, not applicable; NOR, Norway; PRT, Portugal; SVN, Slovenia; SWE, Sweden.
Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

* Country participated in both COSI rounds and a new sample of schools was included in Round 2; † Country participated in both COSI rounds and the same schools as in Round 1 were included in Round 2; ‡ Data from four schools in Madeira, collected one year after the other Portuguese regions, were not taken into account in this paper; § The primary sampling unit were paediatric clinics and not primary schools. The schools of the measured children were, however, asked to complete the school form.

	LVA		LTU		MLT		NOR		PRT		SVN		SWE	
	1	2*	1	2†	1	2	1	2†	1‡	2†,‡	1	2*	1	2
	7	7	7	7,9	6	–	8	8	7	7	6,7,8	6,7,8,9	7,8	–
	193	174	161	164	95	–	131	131	185	185	118	167	220	–
	190	169	155	162	95	–	127	125	177	172	118	167	94	–
	190	169	155	160	95	–	127	125	176	167	118	167	89	–
	16	15	29	55	29	–	23	20	18	21	99	90	40	–
	2	1	8	12	3	–	2	1	1	2	33	7	11	–
	99	115	79	170	104	–	108	85	50	55	172	228	131	–

Supplementary Table 4.2 Data collection period of the anthropometric measurements and the completion of the school form in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by country

Country	Data collection period (*month/year*)			
	Anthropometric measurements		Completion of school form	
	Round 1	Round 2	Round 1	Round 2
Bulgaria	03/08 – 05/08	–	ND	–
Czech Republic	01/08 – 12/08	01/10 – 12/10	01/08 – 09/09	01/10 – 03/11
Greece	–	11/10 – 03/11	–	11/10 – 03/11
Hungary	–	04/10 – 06/10	–	04/10 – 06/10
Ireland	04/08 – 06/08	10/10 – 11/10	04/08 – 09/08	10/10 – 11/10
Latvia	02/08 – 03/08	03/10 – 04/10	02/08 – 03/08	03/10 – 04/10
Lithuania	04/08 – 05/08	02/10 – 05/10	03/08 – 05/08	03/10 – 05/10
Malta	04/08 – 06/08	–	04/08 – 08/08	–
Norway	09/08 – 11/08	09/10 – 12/10	09/08 – 11/08	09/10 – 12/10
Portugal	05/08 – 06/08	04/10 – 12/10	05/08 – 07/08	05/10 – 12/10
Slovenia	04/08 – 04/08	04/10 – 04/10	12/08 – 12/08	05/10 – 05/10
Sweden	03/08 – 06/08	–	03/08 – 11/08	–

Abbreviations: –, no participation; COSI, Childhood Obesity Surveillance Initiative; ND, not determined.

Supplementary Table 4.3 Number of schools that completed a school form in COSI Round 1 (2007/2008) and COSI Round 2 (2009/2010), by total number of mandatory school environmental characteristics for which information was provided and country

Total number of mandatory school environmental characteristics for which information was provided	Countries																									
	BGR		CZE		GRC		HUN		IRL		LVA		LTU		MLT		NOR		PRT		SVN		SWE	
	COSI data collection round																							
	1[a]	2	1[b]	2[c]	1	2[d]	1	2[e]	1	2[f]	1	2[g]	1[h]	2[i]	1	2	1[j]	2[k]	1[l]	2[m]	1[n]	2	1[o]	2
	Number of schools (*n*)																							
<13	0	–	0	0	–	0	–	0	0	0	0	0	0	0	0	–	0	0	0	0	0	0	0	–
13	0	–	0	0	–	0	–	0	0	0	0	0	0	0	0	–	1	1	0	0	0	0	0	–
14	0	–	0	0	–	0	–	0	0	0	0	0	0	0	0	–	0	0	0	0	0	0	0	–
15	0	–	109	381	–	14	–	0	0	0	0	0	1	3	0	–	0	0	0	0	0	0	0	–
16	5	–	6	20	–	1	–	1	0	1	0	1	9	9	0	–	0	0	6	2	0	0	47	–
17	13	–	14	33	–	7	–	4	0	10	0	2	14	27	0	–	7	6	14	6	5	0	5	–
18	161	–	419	448	–	101	–	93	154	143	190	166	131	121	95	–	119	118	156	159	113	167	37	–

Abbreviations: –, no participation; BGR, Bulgaria; COSI, Childhood Obesity Surveillance Initiative; CZE, Czech Republic; GRC, Greece; HUN, Hungary; IRL, Ireland; ISO, International Organization for Standardization; LTU, Lithuania; LVA, Latvia; MLT, Malta; NOR, Norway; PRT, Portugal; SVN, Slovenia; SWE, Sweden.

Note. The country codes refer to the ISO 3166-1 alpha-3 country codes and countries were listed in alphabetical order by their full names.

[a] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 2), 'provision of physical education to pupils from participating classes' (*n* = 7) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 14); [b] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 117), 'provision of physical education to pupils from participating classes' (*n* = 120) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 116); [c] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 395), 'provision of physical education to pupils from participating classes' (*n* = 409) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 412); [d] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 17), 'provision of physical education to pupils from participating classes' (*n* = 15) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 19); [e] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 1), 'provision of physical education to pupils from participating classes' (*n* = 2) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 3); [f] Information was not provided by some schools on the characteristics 'salted snacks can be obtained on the school premises' (*n* = 1), 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 8), 'provision of physical education to pupils from participating classes' (*n* = 2) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 1); [g] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 2) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 2); [h] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 2), 'provision of physical education to pupils from participating classes' (*n* = 9) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 24); [i] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 17), 'provision of physical education to pupils from participating classes' (*n* = 14) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 23); [j] Information was not provided by some schools on the characteristics 'cold drinks without sugar can be obtained on the school premises' (*n* = 1), 'cold drinks containing sugar can be obtained on the school premises' (*n* = 1), 'hot drinks without sugar can be obtained on the school premises' (*n* = 1), 'hot drinks containing sugar can be obtained on the school premises' (*n* = 1), 'diet or 'light' soft drinks can be obtained on the school premises' (*n* = 1), 'provision of physical education to pupils from participating classes' (*n* = 1) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 6); [k] Information was not provided by some schools on the characteristics 'cold drinks without sugar can be obtained on the school premises' (*n* = 1), 'cold drinks containing sugar can be obtained on the school premises' (*n* = 1), 'hot drinks without sugar can be obtained on the school premises' (*n* = 1), 'hot drinks containing sugar can be obtained on the school premises' (*n* = 1), 'diet or 'light' soft drinks can be obtained on the school premises' (*n* = 1), 'provision of physical education to pupils from participating classes' (*n* = 5) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 1); [l] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 4), 'provision of physical education to pupils from participating classes' (*n* = 14) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 8); [m] Information was not provided by some schools on the characteristics 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 2), 'provision of physical education to pupils from participating classes' (*n* = 3) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 5); [n] Information was not provided by some schools on the characteristics 'fresh fruit can be obtained on the school premises' (*n* = 2), 'diet or 'light' soft drinks can be obtained on the school premises' (*n* = 1), 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 1) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 1); [o] Information was not provided by some schools on the characteristics 'flavoured milk can be obtained on the school premises' (*n* = 1), 'availability of outside playgrounds or inside play areas where children can play during school breaks' (*n* = 1), 'provision of physical education to pupils from participating classes' (*n* = 47) and 'any initiatives/projects organized to promote a healthy lifestyle among pupils from participating classes' (*n* = 50).

5

WHO European Childhood Obesity Surveillance Initiative: health-risk behaviours on nutrition and physical activity in 6–9-year-old schoolchildren

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(With kind permission from the WHO Regional Office for Europe)

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ABSTRACT

Objective: To assess to what extent eight behavioural health risks related to breakfast and food consumption and five behavioural health risks related to physical activity, screen time and sleep duration are present among schoolchildren, and to examine whether health-risk behaviours are associated with obesity.

Design: Cross-sectional design as part of the European Childhood Obesity Surveillance Initiative of the World Health Organization (school year 2007/2008). Children's behavioural data were reported by their parents and children's weight and height measured by trained fieldworkers. Descriptive statistics and logistic regression analyses were performed.

Setting: Primary schools in Bulgaria, Lithuania, Portugal and Sweden; paediatric clinics in the Czech Republic.

Subjects: Nationally representative samples of 6–9-year-olds (n = 15 643).

Results: All 13 risk behaviours differed statistically significantly across countries. Highest prevalence estimates of risk behaviours were observed in Bulgaria and lowest in Sweden. Not having breakfast daily and spending screen time ≥ 2 hours/day were clearly positively associated with obesity. The same was true for eating 'foods like pizza, French fries, hamburgers, sausages or meat pies' > 3 days/week and playing outside < 1 hour/day. Surprisingly, other individual unhealthy eating or less favourable physical activity behaviours showed either no or significant negative associations with obesity. A combination of multiple less favourable physical activity behaviours showed positive associations with obesity, whereas multiple unhealthy eating behaviours combined did not lead to higher odds of obesity.

Conclusions: Despite a categorization based on international health recommendations, individual associations of the 13 health-risk behaviours with obesity were not consistent, whereas presence of multiple physical activity-related risk behaviours was clearly associated with higher odds of obesity.

INTRODUCTION

The determinants of childhood obesity are complex and numerous[1]. Mostly, it is generally accepted that individual eating and physical activity patterns as well as sedentary behaviours are important contributors[2]. Alongside an increase of overweight and obesity levels in children observed during the last decades at the global[3–5] and European levels[2,6], in many countries a shift has been observed from diets based mainly on unprocessed foods to diets high in fat, sugar and salt[7]. Simultaneously, trends towards decreased habitual physical activity levels and increased sedentary behaviours (such as screen time) have been observed[7]. Lifestyle behaviours related to diet and physical activity tend to track from childhood into adulthood[8] and children with excess body weight are likely to stay overweight or obese in adulthood[9]. Obesity preventive measures aiming to improve diets and physical activity would thus be priority actions during childhood[1,6].

Monitoring dietary patterns and physical activity levels would ideally be part and parcel of an obesity surveillance system[10] and is important for evaluating policy implementation and combating the obesity epidemic[2]. The European Childhood Obesity Surveillance Initiative (COSI) was initiated in 2006 by the Regional Office for Europe of the World Health Organization (WHO) and some Member States as a follow-up to the WHO *European Charter on Counteracting Obesity*[11]. COSI is a population-based monitoring system that measures at regular intervals the levels of overweight and obesity (based on mandatory measurements of the children's weight and height) among primary-school children aged 6–9 years in the WHO European Region. The COSI protocol also includes the administration on a voluntary basis of a family form that gathers information on children's lifestyle behaviours such as food consumption frequency, physical activity, screen time and sleep duration, as well as on family socioeconomic characteristics. Countries could choose all or just some of the questions in this family form[12]. The first COSI data collection round took place in school year 2007/2008 in which 13 countries (Belgium (Flanders only), Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden) participated. All these countries except Cyprus had a complete set of children's data on weight and height measurements, and five countries also had a complete set of children's data on dietary intake and physical activity indicators. The present paper describes the findings of these five countries (Bulgaria, Czech Republic, Lithuania, Portugal and Sweden) that collected data on all questions related to children's lifestyle behaviours on the family form and provided their data to WHO according to the COSI protocol[13].

The purposes of the current study were to assess to what extent behavioural health risks related to diet and physical activity are present among 6–9-year-old children in five European countries and to examine whether health-risk behaviours are associated with overweight and obesity.

METHODS

Sampling of children

Countries applied a nationally representative school-based cluster sampling design, whereby primary schools were the primary sampling units (PSUs) (except the Czech Republic, where the PSU was composed of paediatric clinics). Primary schools were selected randomly from the list of all primary schools centrally available in each country through the Ministry of Education or the national school registry (or in the Czech Republic, the national list of primary-care paediatricians). Anthropometric outcome measures, such as body mass index (BMI), were the initial main outcomes of interest of COSI implementation. Stratification of the PSU was therefore applied if it was expected that differences in these measures across strata would be observed. This was done by the Czech Republic by region and level of urbanization and by Lithuania by district and level of urbanization. Information on the urbanization grade of the children's residence, using the three pre-defined options 'urban', 'semi-urban' or 'rural' in all countries, was obtained. Classes formed the secondary sampling units and subsequently all children registered in the sampled classes were approached for their participation. Detailed sampling characteristics have been described elsewhere[12,14].

COSI targets children aged 6, 7, 8 and 9 years old, whereby countries could choose one or more of these four age groups. If all children of the specifically targeted age group were in the same grade, then one class per school was drawn within a grade level. If the specifically targeted age group was spread across grades, however, all grades where children from this age group were present could be sampled. The majority of the 13 countries that participated in the first data collection round targeted one age group, including the five countries that are the subject of the present paper's research. Bulgaria, the Czech Republic, Lithuania and Portugal targeted 7-year-olds and Sweden targeted 7- and 8-year-olds. All children in the sampled classes who were younger than six years or older than nine years were excluded from the analyses (n = 18). Moreover, data from Madeira, collected one year after the other Portuguese regions, were not included in the present Portuguese data.

COSI family record form

The COSI family record form was based partly on the questionnaire used in the 2001/2002 round of the Health Behaviour in School-aged Children (HBSC) study that surveys 11-, 13- and 15-year-olds[15]. The form was given directly to the parents, sent home with the child or mailed to the child's home, and it was often attached to the letter informing parents about the survey and asking for their consent. The form was completed by the children's parents or caregivers, possibly together with their child. Table **5.1** lists the questions and their pre-defined answer options that were included in the form to collect data on the children's lifestyle behaviours and on parental socioeconomic status by describing their educational and

occupational level, and were subject of the present paper's research. A complete overview of all questions that were included in the COSI family record form can be found elsewhere[12]. For the paper's statistical analyses, the answer options of the children's related items were categorized into 'healthy behaviours' vs. 'health-risk behaviours' (see also Table **5.1**), whereby the categorization was based on international health recommendations as follows:

- Breakfast consumption frequency: daily breakfast consumption is part of a healthy diet and contributes to the quality and quantity of a person's daily dietary intake[16] (as such categorized in the 'healthy behaviour category' in the present paper).
- Food consumption frequency: eight items in the questionnaire related to food consumption frequencies were used for the analyses: (i) 'fresh fruit'; (ii) '100% fruit juice'; (iii) 'vegetables (excluding potatoes)'; (iv) 'soft drinks containing sugar'; (v) 'foods like potato chips (crisps), corn chips, popcorn or peanuts'; (vi) 'foods like candy bars or chocolate'; (vii) 'foods like biscuits, cakes, doughnuts or pies'; and (viii) 'foods like pizza, French fries (chips), hamburgers, sausages or meat pies'. Items (i) to (iii) are good sources of complex carbohydrates, vitamins, minerals and other substances important for good health[17,18] and one of the main food groups that should contribute to a child's daily diet[19]. Daily consumption of these items was considered a 'healthy behaviour' in the present paper. Items (iv) to (viii) tend to have a high content of saturated fats, free sugars or salt, and therefore their consumption should be limited[20]. Consumption of these items ≤ 3 days/week was considered a 'healthy behaviour' in the present paper.
- Physical activity: children and adolescents aged 5–17 years should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least three times weekly. These WHO recommendations represent a minimum target for daily physical activity that allows for health enhancement and prevention of noncommunicable diseases[21]. Active transport, playing outside for ≥ 1 hour/day and performing sport activities for ≥ 2 days/week are in line with the recommended levels for this age group (as such categorized in the 'healthy behaviour category' in the present paper).
- Screen time: guidelines for parents from the American Academy of Pediatrics include the limitation of total media time to no more than 1–2 hours/day[22]. Spending screen time < 2 hours/day was considered a 'healthy behaviour' in the present paper.
- Sleep duration: according to normal sleep characteristics, the usual sleep duration of preschool children aged 4 years is 12–13 hours/day and shows a steady decline with increasing age in schoolchildren aged 5 years onwards. By 10 years of age, the sleep duration is 8–10 hours/day[23]. Sleep duration of ≥ 9 hours/day was considered a 'healthy behaviour' in the present paper.

Table 5.1 Questions and their predefined answer options as included in the COSI family record form to collect data on children's lifestyle behaviours and parental socioeconomic status, and categorization of the answer options for the paper's analyses

Questions	Answer options	Categorization of answer options for the paper's analyses
Items on children		
Breakfast consumption frequency		
'Over a typical or usual week, how often does your child have breakfast?'	'Every day'; 'most days (4–6 days)'; 'some days (1–3 days)'; 'never'	⇒ Every day* = 'every day' ⇒ < 7 days/week† = 'most days (4–6 days)', 'some days (1–3 days)' or 'never'
Food consumption frequency		
'Over a typical or usual week, how often does your child eat or drink the following kinds of foods or beverages? (i) 'Fresh fruit'; (ii) '100% fruit juice'; (iii) 'vegetables (excluding potatoes)'; (iv) 'soft drinks containing sugar'; (v) 'foods like potato chips (crisps), corn chips, popcorn or peanuts'; (vi) 'foods like candy bars or chocolate'; (vii) 'foods like biscuits, cakes, doughnuts or pies'; (viii) 'foods like pizza, French fries (chips), hamburgers, sausages or meat pies''	'Every day'; 'most days (4–6 days)'; 'some days (1–3 days)'; 'never'	Food items (i) to (iii)‡: ⇒ Every day* = 'every day' ⇒ < 7 days/week† = 'most days (4–6 days)', 'some days (1–3 days)' or 'never' Food items (iv) to (viii): ⇒ ≤ 3 days/week* = 'some days (1–3 days)' or 'never' ⇒ > 3 days/week† = 'every day' or 'most days (4–6 days)'
Physical activity		
'How does your child usually get to and from school? Please tick one box for 'Going to school' and one box for 'Coming from school''	'S/he usually takes the school bus'; 's/he usually goes by public transport'; 's/he is usually brought by car'; 's/he usually rides a bicycle'; 's/he usually walks'; 'other'	⇒ Active (both routes)* = 's/he usually rides a bicycle' or 's/he usually walks' ⇒ Inactive (both routes)† = 's/he usually takes the school bus', 's/he usually goes by public transport', 's/he is usually brought by car' or other means of inactive transport ⇒ Combined (one route 'active' and one route 'inactive')

'Is your child a member of one or more sports or dancing clubs (e.g. football, running, hockey, swimming, tennis, basketball, gymnastics, ballet, fitness, ballroom dancing, etc.)?'	'Yes'; 'no'	⇒ ⇒	≥ 2 days/week* = '2 days a week', '3 days a week', '4 days a week', '5 days a week', '6 days a week' or '7 days a week' < 2 days/week† = '0 days a week', '1 day a week' or 'not being a member of one or more sports or dancing club(s)'
'Over a typical or usual week, on how many days does your child go to this/these sports or dancing club(s)?'	'0 days a week'; '1 day a week'; '2 days a week'; '3 days a week'; '4 days a week'; '5 days a week'; '6 days a week'; '7 days a week'		
'In his/her free time, about how many hours per day does your child usually play outside, at home or somewhere else? Please tick one box for weekdays and one box for weekends'	'Never'; 'less than 1 hour per day'; 'about 1 hour per day'; 'about 2 hours per day'; 'about 3 or more hours per day'	⇒ ⇒	≥ 1 hour/day*,§ < 1 hour/day†,§
Screen time			
'In his/her free time, about how many hours per day does your child usually spend using a computer for playing games (other than homework), at home or somewhere else? Please tick one box for weekdays and one box for weekends'	'Never'; 'less than 1 hour per day'; 'about 1 hour per day'; 'about 2 hours per day'; 'about 3 or more hours per day'	⇒ ⇒	< 2 hours/day*,¶ ≥ 2 hours/day†,¶
'In his/her free time, about how many hours per day does your child usually spend watching television (including videos), at home or somewhere else? Please tick one box for weekdays and one box for weekends'	'Never'; 'less than 1 hour per day'; 'about 1 hour per day'; 'about 2 hours per day'; 'about 3 or more hours per day'		
Sleep duration			
'What is your child's usual amount of sleep each day?'	___ hours and __minutes (combining night-time sleep and naps)	⇒ ⇒	≥ 9 hours/day* < 9 hours/day†

Table 5.1 (*Contd.*)

Questions	Answer options	Categorization of answer options for the paper's analyses
Items on parents		
Education		
'What is the highest level of education you and/or your spouse/partner have completed? Please select one answer only for each of you'	'Primary school'; 'secondary school'; 'undergraduate/ bachelor's degree'; 'master's degree or higher'	Maximum educational level of both parents: ⇒ Low = both parents 'primary school' or 'secondary school' ⇒ High = at least one parent 'undergraduate/ bachelor's degree' or 'master's degree or higher'
Occupation		
'Which of the following best describes your and/or your spouse's/partner's main work over the last 12 months? Please select one answer only for each of you'	'Government employed'; 'non-government employed'; 'self-employed'; 'student'; 'homemaker'; 'unemployed, able to work'; 'unemployed, unable to work'; 'retired'	⇒ Both unemployed = both parents 'student', 'homemaker', 'unemployed, able to work', 'unemployed, unable to work' or 'retired' ⇒ One or both employed = at least one parent 'government employed', 'non-government employed' or 'self-employed'

Abbreviation: COSI, Childhood Obesity Surveillance Initiative.

* 'Healthy behaviour' category, which served as the reference category in the logistic regression analyses; † 'Health-risk behaviour' category, which served as the exposure of interest and was used for the calculation of the three risk behaviour scores; ‡ The answers for the two items 'fresh fruit' and '100% fruit juice' were combined into 'every day' (at least one of the items was categorized in 'every day') and '< 7 days/week' (both items were categorized in '< 7 days/week'); § Numerical values were assigned to the items 'playing outside on a weekday' and 'playing outside on a weekend day' enabling the conversion of this item to a numerical scale ('never' = 0; 'less than 1 hour per day' = 0.5; 'about 1 hour per day' = 1; 'about 2 hours per day' = 2; 'about 3 or more hours per day' = 3). Usual outside play time per day was calculated weighing weekday (5/7) and weekend hours (2/7) accordingly; ¶ Numerical values were assigned to the items 'using a computer' and 'watching television' on a weekday or a weekend day enabling the conversion of these two items to a numerical scale ('never' = 0; 'less than 1 hour per day' = 0.5; 'about 1 hour per day' = 1; 'about 2 hours per day' = 2; 'about 3 or more hours per day' = 3). Total screen time per day was calculated as the sum of the two items weighing weekday (5/7) and weekend hours (2/7) accordingly.

Food and physical activity risk behaviour scores

A 'food-risk behaviour score' and a 'physical activity-risk behaviour score' were created for each child based on the presence of eight food-related and five physical activity-related (including screen time and sleep duration) health-risk behaviours, respectively (see Table **5.1**). One point was assigned to the presence of each risk behaviour and subsequently all points were added together. The 'food-risk behaviour score' could range from zero (none of the food-risk behaviours present) to eight points (all food-risk behaviours present), the food-risk behaviours being:

1. having breakfast < 7 days/week;
2. eating fruit < 7 days/week;
3. eating vegetables (excluding potatoes) < 7 days/week;
4. drinking soft drinks containing sugar > 3 days/week;
5. eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week;
6. eating foods like candy bars or chocolate > 3 days/week;
7. eating foods like biscuits, cakes, doughnuts or pies > 3 days/week; and
8. eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies > 3 days/week.

The 'physical activity-risk behaviour score' could range from zero (none of the physical activity-risk behaviours present) to five points (all physical activity-risk behaviours present), the physical activity-risk behaviours being:

1. using inactive transportation going to and from school;
2. going to a sports or dancing club < 2 days/week;
3. playing outside < 1 hour/day;
4. spending screen time ≥ 2 hours/day; and
5. sleep duration < 9 hours/day.

In addition, a 'health-risk behaviour score' was created for each child by combining the 'food-risk behaviour score' and the 'physical activity-risk behaviour score' ranging from zero (none of the health-risk behaviours present) to 13 points (all health-risk behaviours present). The three scores were assigned only to the children with no missing values for any of the 13 health-risk behaviours under study.

Weight and height measurements

Children's weight and height were measured by fieldworkers who were trained in measuring according to WHO standardized techniques[13,24]. Children were asked to take off their shoes and socks, as well as all heavy clothing and to remove items such as wallets or mobile phones. The clothes worn by a child during the weight and height measurements were noted by using four pre-defined types of clothing: 'underwear only', 'gym clothes (e.g. shorts and

t-shirt only)', 'light clothing (e.g. t-shirt, cotton trousers or skirt)' or 'heavy clothing (e.g. sweater and jeans)'. Body weight was measured to the nearest 0.1 kg with portable digital (mainly manufacturer-calibrated) scales and body height was measured standing upright to the nearest 0.1 cm with portable stadiometers. Body weight was adjusted for the weight of the clothes worn, whereby the average weights of types of clothing were provided by each country. BMI was calculated using the formula: adjusted weight/height^2 (kg/m^2). The 2007 WHO recommended growth reference[25] for school-age children was used to compute BMI-for-age (BMI/A) Z-scores. Children who did not have biologically plausible values (i.e. a BMI/A Z-score between –5 and +5[26]) were excluded from the analyses (n = 31). Thinness was defined as the proportion of children with a BMI/A value < –2 Z-scores (BMI/A value below –2 standard deviation (SD) relative to the median BMI/A of the 2007 WHO growth reference)[25], normal weight as the proportion of children with a BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score, overweight as the proportion of children with a BMI/A value above +1 Z-score, obesity as the proportion of children with a BMI/A value above +2 Z-scores and pre-obesity as the proportion of children with a BMI/A value > +1 Z-score and ≤ +2 Z-scores. The prevalence estimates for overweight children include those who are obese and the prevalence estimates for obese children exclude those who are pre-obese[24]. The three physical status categories 'normal weight', 'overweight' and 'obese' were used as outcome measures in the analyses.

Statistical analyses

For each country-specific dataset, the Shapiro–Francia test was used to assess whether the three calculated risk behaviour scores were normally distributed. Preliminary analyses revealed that all country-specific food-risk behaviour and health-risk behaviour scores were skewed, and thus the final descriptive analyses included the calculation of their medians and quartiles. Mean and SD were computed for continuous normally distributed variables and percentage for categorical variables. Differences in percentages and medians across the countries were examined using the chi-squared test and the Kruskal–Wallis test, respectively. If the chi-squared tests were found significant, the Marascuilo procedure[27] was used for the multi-group comparisons of proportions between countries.

Bivariate multilevel logistic regression analyses were performed, and odds ratios (ORs) along with 95% confidence intervals (CIs) were obtained by country to explore associations between each of the 13 children's health-risk behaviours individually (exposure variables) and the odds of being overweight as well as the odds of being obese (compared with normal weight children). The association was considered positive when a health-risk behaviour was associated with higher odds of the outcome of interest (overweight or obesity), and the association was considered negative when the health-risk behaviour was associated with lower odds of the outcome.

Nine of the preliminary country-specific analyses performed, to test the interaction between the sex of the child and each of the 13 behaviours associated with overweight or with obesity, indicated that the analyses needed to be stratified by sex. All country-specific final analyses were therefore adjusted for the children's sex and age, and included random effects for the PSU (schools in Bulgaria, Lithuania, Portugal and Sweden; paediatric clinics in the Czech Republic) to account for the clustered study design. The analyses were also done for the five countries together and included the random effects for country as well.

In the multivariable multilevel logistic regression analyses, children from the total study group with a missing value for any of the children's health-risk behaviours (n = 3731), children's residential urbanization grade (n = 77), parental education (n = 1277) or parental occupation were excluded (n = 1710). None of the health-risk behaviours showed multicollinearity, which was tested with Pearson correlation analyses and determined by a correlation coefficient of 0.80 or higher. All health-risk behaviours were included simultaneously in the multivariable analyses and similar adjustments were made as with the bivariate analyses. In addition, the analyses were adjusted for children's residential urbanization grade, parental education and parental occupation because preliminary analyses suggested the presence of an association between each of these three variables individually and children's overweight or obesity in at least one country. This subgroup of children for the multivariable analyses was also used to estimate the odds of being overweight or the odds of being obese being associated with the number of risk behaviours present relative to zero or one of the risk behaviours present. The linear trend test of ORs was performed using the likelihood ratio test.

A P value of < 0.05 was used to define statistical significance. All statistical analyses were performed in Stata version 10.1 (StataCorp LP, College Station, TX, USA).

RESULTS

Children's characteristics

The initial sample included 19 494 children who were present on the day of the measurements and of whom the highest number of refusals was observed in Bulgaria (13.3%) and Sweden (11.8%). Of the 18 183 children with complete information on age, sex and anthropometric measures, 86.3% returned a filled out COSI family form. The subgroup of children without any missing values for the variables used for the multivariable analyses included in total 5126 fewer children (Bulgaria, 27.4%; Czech Republic, 32.2%; Lithuania, 29.6.%; Portugal, 39.9%; and Sweden, 35.5%) than the total study group of 15 643 children.

Table 5.2 summarizes some children's characteristics in the five countries. In the total study group, mean age ranged from 7.0 years in the Czech Republic to 8.4 years in Sweden, and boys and girls were equally represented. The prevalence of overweight ranged from

Table 5.2 Characteristics of the study population by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Characteristic	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
Children who were present on the day of the anthropometric measurements: total (*n*)	3914	1695	4955	3592	5338
Children who participated in the anthropometric measurements: total (*n*)*	3392	1695	4948	3590	4708
Children with complete data on age, sex, weight and height measures: total (*n*)	3381	1692	4939	3590	4581
Children who returned a filled out family form: total (*n*)†	3427	1660	4436	3063	3711
Total study group of children: total (*n*)‡	3267	1633	4084	3026	3633
Mean (SD) age (*years*)	7.7 (0.3)	7.0 (0.3)	7.8 (0.3)	7.5 (0.6)	8.4 (0.6)
Boys (*n*, %)	1619 (49.6)	815 (49.9)	2064 (50.5)	1509 (49.9)	1874 (51.6)
Prevalence of overweight (%)§	28.8[b]	20.9[c]	23.1[c]	37.6[a]	23.2[c]
Prevalence of obesity (%)§	12.4[a]	7.3[b]	8.3[b]	14.6[a]	6.5[b]
Prevalence of normal weight (%)§	68.4[b]	76.3[a]	74.9[a]	61.5[c]	75.6[a]
Prevalence of thinness (%)§	2.9[a]	2.8[a]	2.0[a]	0.9[b]	1.1[b]
Mean (SD) BMI/A Z-score	0.35 (1.36)	0.13 (1.21)	0.27 (1.18)	0.71 (1.20)	0.27 (1.07)
Subgroup of children: total (*n*)¶	2373	1107	2874	1818	2345
Mean (SD) age (*years*)	7.7 (0.3)	7.0 (0.3)	7.8 (0.3)	7.5 (0.6)	8.4 (0.6)
Boys (*n*, %)	1189 (50.1)	543 (49.1)	1475 (51.3)	901 (49.6)	1247 (53.2)
Prevalence of overweight (%)§	29.3[b]	20.1[c]	24.5[c]	37.7[a]	22.6[c]
Prevalence of obesity (%)§	12.6[a]	7.4[b,c]	8.9[b]	13.8[a]	5.8[c]
Prevalence of normal weight (%)§	68.1[b]	77.2[a]	73.5[a]	61.6[c]	76.1[a]
Prevalence of thinness (%)§	2.6[a]	2.7[a,b]	2.0[a,b]	0.7[c]	1.3[b,c]
Mean (SD) BMI/A Z-score	0.38 (1.36)	0.13 (1.22)	0.30 (1.20)	0.70 (1.19)	0.25 (1.07)

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative; SD, standard deviation; WHO, World Health Organization.

[a,b,c] Proportions within a row with unlike superscript letters were significantly different (Marascuilo procedure). Superscripts are ranked by decreasing prevalence, whereby the highest prevalence was indicated with superscript a; * All children who agreed to have their weight and height measured, including children with missing information on age or sex; † Out of the children who returned a filled out family form, 3285 Bulgarian, 1649 Czech, 4089 Lithuanian, 3032 Portuguese and 3637 Swedish children had complete information on age, sex, weight and height measures; ‡ Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range ($\geq -5 - \leq +5$), and who returned a filled out family record form; § Overweight is defined as the proportion of children with a BMI/A value > +1 Z-score (i.e. BMI/A above +1 SD relative to the median BMI/A of the 2007 WHO growth reference)[25], obesity as the proportion of children with a BMI/A value > +2 Z-scores, normal weight as the proportion of children with a BMI/A value ≥ -2 and $\leq +1$ Z-score, and thinness as the proportion of children with a BMI/A value < –2 Z-scores. Statistically significant difference in proportions across the countries (chi-squared test; $P < 0.001$); ¶ All criteria for the total study group of children, as well as no missing values for the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation.

20.9% to 37.6% and the prevalence of obesity ranged from 6.5% to 14.6%. The prevalence figures of Czech, Lithuanian and Swedish children did not differ from each other, but their values were statistically significantly lower than those of Bulgarian and Portuguese children. The subgroup of children without missing values on any of the health-risk behaviours, children's residential urbanization grade, parental education and parental occupation showed similar patterns (Table 5.2).

Outcomes on the educational level and the main occupation over the last 12 months of the children's parents as well as the children's residential urbanization grade are given in Supplementary Table 5.1. In summary, the percentage of parents with either primary school or secondary school as their highest completed educational level was 37.9% in Lithuania, 49.3% in Sweden, 62.0% in the Czech Republic, 63.2% in Bulgaria and 80.2% in Portugal. Unemployment of both parents varied between 2.0% and 3.6% in the Czech Republic, Lithuania, Portugal and Sweden and was 10.4% in Bulgaria. The children's residential area was mainly urban in Bulgaria (78.8%), Portugal (66.4%) and in the Czech Republic (47.8%), mainly semi-urban in Lithuania (40.9%) and mainly rural in Sweden (55.3%).

Breakfast and food consumption frequencies

Supplementary Table 5.2 presents the proportion of consumption frequencies of breakfast and eight food items over a usual week for each answer category in the five countries. The first part of Table 5.3 is derived from Supplementary Table 5.2 and presents the frequencies of food-related health-risk behaviours. As shown in Table 5.3, the prevalence of all food-related risk behaviours differed statistically significantly across the countries. Less favourable food behaviours (shown by lower-ranked superscripts, e.g. a and b) were mainly found in Bulgaria and more favourable food behaviours in Sweden (shown by higher-ranked superscripts, e.g. d and e). Almost 40% or more of the Bulgarian children ate foods like 'pizza, French fries (chips), hamburgers, sausages or meat pies', 'biscuits, cakes, doughnuts or pies', 'potato chips (crisps), corn chips, popcorn or peanuts' or 'candy bars or chocolate' > 3 days/week, while 6% or fewer of the Swedish children did so. The percentage of children who did not have breakfast every day ranged from 4.4% in Portugal to 32.5% in Lithuania.

Table 5.3 Prevalence (%) of children's health-risk behaviours in the total study group* by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Health-risk behaviour		Countries				
		Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
		%				
Breakfast and food consumption frequency						
1	Having breakfast < 7 days/week†	21.1[b]	24.3[b]	32.5[a]	4.4[c]	5.7[c]
2	Eating fruit‡ < 7 days/week†	64.3[a]	46.8[b]	62.8[a]	35.0[c]	31.2[d]
3	Eating vegetables (excluding potatoes) < 7 days/week†	76.4[a]	71.7[b]	76.8[a]	60.6[c]	46.6[d]
4	Drinking soft drinks containing sugar > 3 days/week†	38.6[b]	46.5[a]	19.5[c]	20.2[c]	8.5[d]
5	Eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week†	46.5[a]	4.3[c]	9.7[b]	5.5[c]	1.1[d]
6	Eating foods like candy bars or chocolate > 3 days/week†	63.4[a]	24.4[c]	44.0[b]	11.7[d]	2.2[e]
7	Eating foods like biscuits, cakes, doughnuts or pies > 3 days/week†	46.4[a]	24.2[c]	33.3[b]	25.8[c]	6.4[d]
8	Eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies > 3 days/week†	39.4[a]	2.2[c]	7.3[b]	6.6[b]	2.0[c]
Physical activity						
9	Using inactive transportation going to and from school†	29.3[d]	38.8[c]	39.2[c]	66.9[a]	47.8[b]
10	Going to a sports or dancing club < 2 days/week†	79.0[a]	64.3[c]	69.4[b]	70.5[b]	48.8[d]
11	Playing outside < 1 hour/day†	4.8[c]	5.2[c]	7.5[b]	35.0[a]	7.7[b]
Screen time and sleep duration						
12	Spending screen time ≥ 2 hours/day†	70.3[b]	32.6[d]	74.2[a]	34.7[d]	39.5[c]
13	Sleep duration < 9 hours/day†	19.1[a]	5.6[c]	11.9[b]	13.1[b]	3.5[d]

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative.

[a,b,c,d,e] Within each health-risk behaviour item, proportions with unlike superscript letters were significantly different (Marascuilo procedure). Superscripts are ranked by decreasing prevalence, whereby the highest prevalence was indicated with superscript a; * Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), and who returned a filled out family record form; † Statistically significant difference in proportions across the countries (chi-squared test; $P < 0.001$); ‡ Combination of 'fresh fruit' and '100% fruit juice'.

Physical activity, screen time and sleep duration

Supplementary Table 5.3 presents the proportion of items related to physical activity and screen time for each answer category in the five countries. The second part of Table 5.3 is derived from Supplementary Table 5.3 and presents the frequencies of physical activity-related health-risk behaviours. As shown in Table 5.3, the prevalence of all physical activity-related risk behaviours differed statistically significantly across the countries. Less favourable physical activity-related behaviours were found in Bulgaria and Portugal and more favourable physical activity-related behaviours mainly in the Czech Republic. The majority of the Bulgarian (79.0%) and Portuguese (70.5%) children did not go to a sports or dancing club at all or only once weekly, and 35% of the Portuguese children did not play outside for ≥ 1 hour/day. More than 70% of the Bulgarian and Lithuanian children participated in screen time ≥ 2 hours/day, whereas the percentage in the other three countries ranged between 30% and 40%.

Food and physical activity risk behaviour scores

A food-risk behaviour score of maximum eight (not favourable on any of the behaviours) was found in 0.2% of the total subgroup of children (*n* = 10 517) and a physical activity-risk behaviour score of maximum five in 0.3%. A food-risk behaviour score of zero (favourable on all behaviours) was found in 14.3% of the total subgroup of children and a physical activity-risk behaviour score of zero in 7.9%. None of the children had the maximum health-risk behaviour score of 13 and 2.2% of the children had a health-risk behaviour score of zero. Table 5.4 displays the median values of the three calculated risk behaviour scores (based on the presence of food-related and physical activity-related health-risk behaviours). On average, Bulgarian children had the highest food-risk and health-risk behaviour scores and Swedish children the lowest.

Associations with obesity and overweight

For the group of children in the five countries, statistically significant bivariate associations (with adjustment for children's sex and age) with obesity were found in four food-related risk behaviours (Table 5.5), whereas significant multivariable associations (with adjustment for children's sex and age, all 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation) were seen in five food-related risk behaviours (Table 5.6). Children were more likely to be obese when they did not have breakfast every day or ate 'foods like pizza, French fries (chips), hamburgers, sausages or meat pies' > 3 days/week, while children were less likely to be obese when they did not eat fruit every day or ate 'foods like potato chips (crisps), corn chips, popcorn or peanuts' or 'foods like biscuits, cakes, doughnuts or pies' > 3 days/week (Table 5.6). Playing outside < 1 hour/day and spending screen time ≥ 2 hours/day were the only physical activity-related risk behaviours that were statistically significantly associated with higher odds of obesity in the total group or in a country (in both bivariate and multivariable models).

Table 5.4 Median values of the 'food-risk behaviour score', 'physical activity-risk behaviour score' and 'health-risk behaviour score', in a subgroup of children without missing data*, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Score	Countries					
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden	Total five countries
	Median (Q1–Q3)					
Food-risk behaviour score[†,‡]	4 (3–5)	2 (1–3)	3 (2–4)	1 (1–2)	1 (0–2)	2 (1–3)
Physical activity-risk behaviour score[§,‡]	2 (2–3)	1 (1–2)	2 (1–3)	2 (1–3)	1 (1–2)	2 (1–2)
Health-risk behaviour score[¶,‡]	6 (4–7)	4 (3–5)	5 (4–6)	4 (3–5)	2 (1–3)	4 (3–6)

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative; Q1, first quartile; Q3, third quartile.

* Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), who returned a filled out family record form, and who had no missing values on the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation; † Possible range: 0–8; ‡ Statistically significant difference in median scores across the countries (Kruskal–Wallis test; $P = 0.0001$); § Possible range: 0–5; ¶ Possible range: 0–13.

For the group of children in the five countries, the bivariate analyses for overweight indicated statistically significant associations between the same four food-related risk behaviours and overweight as well as between spending screen time ≥ 2 hours/day and overweight (Supplementary Table 5.4) as were found with the bivariate analyses for obesity (Table 5.5). The physical activity-related risk behaviour playing outside for < 1 hour/day was not associated with overweight in both the bivariate and the multivariable analyses. Furthermore, eating 'foods like pizza, French fries (chips), hamburgers, sausages or meat pies' on > 3 days/week did not lead to statistically significant higher odds of overweight (Supplementary Table 5.5), as was shown with the multivariable analyses for obesity (Table 5.6).

Table 5.7 presents the associations between the three calculated risk behaviour scores and obesity. For the group of children in the five countries, none of the food-risk behaviour scores showed a statistically significant association with obesity. A country-specific statistically significant positive association between the food-risk behaviour score of one and obesity was only found in Sweden, whereas the other scores did not reach the statistical significance level. The physical activity-risk behaviour score showed positive associations with obesity at the total group level, whereby children with a score of two to four were more likely to be obese than children with a score of zero. Country-specific positive associations between the physical activity-risk behaviour score and obesity also reached the statistical significance level in Lithuania and Sweden. Compared with children with a combined health-risk behaviour score of zero or one, the higher the score the more likely children were obese in most categories (both in the total group and in Sweden).

Supplementary Table 5.6 shows the associations between the three risk behaviour scores and overweight. Same as with obesity (Table 5.7), none of the food-risk behaviour scores were associated with overweight. The presence of two to four physical activity-related risk behaviours was clearly associated with higher odds of overweight, whereas the combination of four food- and physical activity-related risk behaviours only was positively associated with overweight.

DISCUSSION

We assessed the prevalence of 13 health-risk behaviours related to food consumption frequencies and physical activity among primary-school children in five European countries and examined their association, both individually and combined, with obesity and overweight. The highest prevalence of many risk behaviours was observed in Bulgaria and the lowest in Sweden, whereas the other three countries did not show a clear country order ranking pattern across the behaviours. For instance, Portugal was ranked just before Sweden for the food-related but not for the physical activity-related risk behaviours. Bulgarian and Portuguese children were more obese than Czech, Lithuanian and Swedish children. The statistically significant associations found between the food-related risk behaviours and obesity showed contrasting results although they were consistent across the countries, whereas the significant associations between physical activity-related risk behaviours and obesity were all positive. Moreover, the three calculated risk behaviour scores were positively associated with obesity, most pronounced in Swedish children or in the group of children in the five countries.

To our knowledge, nationally representative European-wide studies collecting data on behaviours related to both nutrition and/or physical activity, as well as using a common data collection protocol, are scarce. Two studies, both targeting adolescents, could be identified: the HBSC targeting 11-, 13- and 15-year-olds[16] and the 'EuropeaN Energy balance Research to prevent excessive weight Gain among Youth (ENERGY)' project targeting 10–12-year-olds[28]. We could compare our results with those for one behaviour only in each of these two studies. The other behavioural indicators that were given in their reports were defined differently or presented in another way. Comparing with the results from the 11-year-olds in the HBSC survey from 2005/2006[16], slight differences in the risk behaviour 'eating fruit < 7 days/week' are seen in HBSC (Portugal, 48%; Bulgaria, 52%; Czech Republic, 57%, Sweden, 59%; and Lithuania, 72%), whereby Bulgaria was grouped in the more favourable and Sweden in the less favourable country group, which is opposite to our data (Table 5.3)[16]. The percentage of children in COSI who did not have breakfast every day (range 4–33%) was on average lower than the percentage found in 10–12-year-old adolescents in the seven European countries participating in the ENERGY project (boys, 17–52%; girls, 12–51%)[28]. This difference may be

Table 5.5 Bivariate associations* between 13 health-risk behaviours and obesity in the total study group†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Health-risk behaviour	Countries					
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden	Total five countries
	OR (95% CI)					
Breakfast and food consumption frequency						
1‡ Having breakfast < 7 days/week	**1.33° (1.03;1.72)**	**2.07°°° (1.37;3.10)**	**1.71°°° (1.35;2.16)**	**1.64° (1.03;2.62)**	1.40 (0.83;2.37)	**1.57°°° (1.36;1.82)**
2‡ Eating fruit§ < 7 days/week	0.85 (0.68;1.06)	1.23 (0.84;1.80)	0.85 (0.67;1.07)	0.86 (0.69;1.08)	0.95 (0.71;1.28)	0.90 (0.80;1.01)
3‡ Eating vegetables (excluding potatoes) < 7 days/week	**0.77° (0.59;0.99)**	1.48 (0.93;2.34)	1.07 (0.81;1.41)	0.99 (0.79;1.23)	1.11 (0.84;1.46)	1.00 (0.89;1.13)
4‡ Drinking soft drinks containing sugar > 3 days/week	0.81 (0.64;1.02)	0.95 (0.65;1.40)	0.99 (0.74;1.32)	1.28 0.98;1.66)	1.31 (0.85;2.03)	1.00 (0.87;1.14)
5‡ Eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week	**0.67°°° (0.53;0.84)**	1.28 (0.53;3.06)	**0.64° (0.41;0.99)**	1.07 (0.68;1.70)	–	**0.72°°° (0.60;0.86)**
6‡ Eating foods like candy bars or chocolate > 3 days/week	0.91 (0.72;1.14)	0.72 (0.45;1.15)	0.79 (0.63;1.01)	0.96 (0.68;1.35)	0.34 (0.08;1.41)	**0.85° (0.74;0.97)**
7‡ Eating foods like biscuits, cakes, doughnuts or pies > 3 days/week	**0.65°°° (0.52;0.81)**	0.61 (0.37;1.00)	0.79 (0.61;1.01)	0.84 (0.65;1.08)	0.71 (0.39;1.31)	**0.74°°° (0.64;0.84)**
8‡ Eating foods like pizza; French fries (chips), hamburgers, sausages or meat pies > 3 days/week	0.89 (0.71;1.12)	2.25 (0.83;6.04)	1.16 (0.77;1.76)	0.92 (0.59;1.43)	1.45 (0.63;3.33)	0.97 (0.82;1.17)
Physical activity						
9‡ Using inactive transportation going to and from school	1.10 (0.86;1.42)	0.71 (0.46;1.08)	1.26 (0.97;1.62)	0.91 (0.70;1.19)	1.19 (0.87;1.63)	1.07 (0.94;1.22)
10‡ Going to a sports or dancing club < 2 days/week	0.81 (0.62;1.06)	1.06 (0.70;1.60)	**1.35° (1.03;1.76)**	1.12 (0.88;1.43)	1.17 (0.88;1.56)	1.09 (0.96;1.23)
11‡ Playing outside < 1 hour/day	**1.65° (1.05;2.60)**	0.71 (0.28;1.80)	**1.50° (1.02;2.20)**	1.04 (0.83;1.31)	1.51 (0.94;2.45)	**1.21° (1.03;1.44)**

Screen time and sleep duration						
12‡ Spending screen time ≥ 2 hours/day	1.16 (0.90;1.50)	**1.64° (1.10;2.46)**	**1.66°°° (1.24;2.24)**	1.24 (0.98;1.57)	**1.73°°° 1.31;2.29)**	**1.43°°° (1.26;1.62)**
13‡ Sleep duration < 9 hours/day	1.03 (0.78;1.36)	0.79 (0.31;2.01)	0.90 (0.62;1.30)	**1.38° (1.02;1.85)**	**2.32°° 1.28;4.22)**	1.15 (0.97;1.36)

Abbreviations: –, no observations for obese children; BMI/A, body-mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.
Notes. Significance levels of ORs: ° $P < 0.05$ °° $P < 0.01$ °°° $P < 0.001$; Significant associations are shown in bold.
* All bivariate analyses were adjusted for the children's sex and age and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or obese children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), and who returned a filled out family record form. Obesity is defined as the proportion of children with a BMI/A value above +2 Z-scores relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ Reference categories for each health-risk behaviour were: 1. having breakfast every day, 2. eating fruit every day, 3. eating vegetables (excluding potatoes) every day, 4. drinking soft drinks containing sugar ≤ 3 days/week, 5. eating foods like potato chips (crisps), corn chips, popcorn or peanuts ≤ 3 days/week, 6. eating foods like candy bars or chocolate ≤ 3 days/week, 7. eating foods like biscuits, cakes, doughnuts or pies ≤ 3 days/week, 8. eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies ≤ 3 days/week, 9. using active transportation going to and from school, 10. going to a sports or dancing club ≥ 2 days/week, 11. playing outside ≥ 1 hour/day, 12. spending screen time < 2 hours/day, and 13. sleep duration ≥ 9 hours/day; § Combination of 'fresh fruit' and '100% fruit juice'.

Table 5.6 Multivariable associations* between 13 health-risk behaviours and obesity in a subgroup of children without missing data†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Health-risk behaviour	Countries					
	Bulgaria (*n* = 1914)	**Czech Republic (*n* = 936)**	**Lithuania (*n* = 2369)**	**Portugal (*n* = 1371)**	**Sweden (*n* = 1922)**	**Total five countries (*n* = 8512)**
	OR (95% CI)					
Breakfast and food consumption frequency						
1‡ Having breakfast < 7 days/week	**1.70°°° (1.26;2.30)**	**1.91° (1.14;3.21)**	**1.80°°° (1.36;2.38)**	**1.88° (1.02;3.46)**	**2.20° (1.12;4.33)**	**1.81°°° (1.52;2.15)**
2‡ Eating fruit§ < 7 days/week	0.78 (0.59;1.03)	0.99 (0.59;1.66)	**0.72° (0.54;0.96)**	0.82 (0.61;1.11)	0.88 (0.58;1.33)	**0.80°° (0.69;0.93)**
3‡ Eating vegetables (excluding potatoes) < 7 days/week	0.83 (0.60;1.14)	1.31 (0.71;2.43)	1.06 (0.74;1.50)	1.01 (0.74;1.36)	1.14 (0.78;1.68)	1.03 (0.88;1.21)
4‡ Drinking soft drinks containing sugar > 3 days/week	1.04 (0.78;1.39)	0.78 (0.48;1.28)	1.17 (0.82;1.69)	1.35 (0.94;1.93)	1.50 (0.85;2.66)	1.09 (0.92;1.30)
5‡ Eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week	**0.66°° (0.49;0.89)**	1.23 (0.36;4.21)	**0.52° (0.27;0.98)**	1.71 (0.75;3.91)	–	**0.66°°° (0.52;0.85)**
6‡ Eating foods like candy bars or chocolate > 3 days/week	1.10 (0.83;1.47)	0.68 (0.36;1.28)	0.85 (0.63;1.14)	0.59 (0.33;1.04)	–	0.89 (0.74;1.06)
7‡ Eating f oods like biscuits, cakes, doughnuts or pies > 3 days/week	**0.69° (0.51;0.94)**	0.69 (0.36;1.31)	0.73 (0.53;1.02)	0.79 (0.56;1.14)	0.73 (0.34;1.57)	**0.74°°° (0.62;0.88)**
8‡ Eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies > 3 days/week	1.23 (0.90;1.68)	2.24 (0.56;8.89)	**1.89° (1.09;3.31)**	1.02 (0.45;2.27)	1.53 (0.52;4.48)	**1.32° (1.04;1.69)**
Physical activity						
9‡ Using inactive transportation going to and from school	1.11 (0.82;1.49)	0.71 (0.42;1.20)	1.16 (0.86;1.58)	1.01 (0.71;1.43)	1.32 (0.89;1.96)	1.12 (0.96;1.30)
10‡ Going to a sports or dancing club < 2 days/week	0.98 (0.72;1.33)	0.88 (0.53;1.47)	1.29 (0.95;1.76)	1.16 (0.84;1.60)	1.02 (0.70;1.49)	1.07 (0.92;1.25)
11‡ Playing outside < 1 hour/day	1.37 (0.80;2.37)	0.63 (0.19;2.16)	**1.59° (1.03;2.45)**	1.02 (0.76;1.37)	1.28 (0.64;2.59)	1.18 (0.95;1.45)

Screen time and sleep duration						
12‡ Spending screen time ≥ 2 hours/day	1.26 (0.94;1.69)	**1.71° (1.04;2.80)**	**1.81°°° (1.27;2.59)**	1.30 (0.96;1.75)	**1.83°°° (1.26;2.65)**	**1.55°°° (1.33;1.81)**
13‡ Sleep duration < 9 hours/day	1.16 (0.84;1.59)	0.77 (0.26;2.25)	0.87 (0.56;1.33)	0.96 (0.63;1.46)	2.17 (0.98;4.78)	1.07 (0.87;1.31)

Abbreviations: –, no observations for obese children and thus this characteristic was excluded from the Swedish multivariable analyses; BMI/A, body mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.
Notes. Significance levels of ORs: ° $P < 0.05$ °° $P \leq 0.01$ °°° $P \leq 0.001$; Significant associations are shown in bold.
* All multivariable analyses were adjusted for the children's sex and age, included all 13 health-risk behaviours simultaneously (except in the Swedish analyses), as well as children's residential urbanization grade, parental education and parental occupation, and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or obese children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), who returned a filled out family record form, and who had no missing values on any of the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation. Obesity is defined as the proportion of children with a BMI/A value above +2 Z-scores relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ Reference categories for each health-risk behaviour were: 1. having breakfast every day, 2. eating fruit every day, 3. eating vegetables (excluding potatoes) every day, 4. drinking soft drinks containing sugar ≤ 3 days/week, 5. eating foods like potato chips (crisps), corn chips, popcorn or peanuts ≤ 3 days/week, 6. eating foods like candy bars or chocolate ≤ 3 days/week, 7. eating foods like biscuits, cakes, doughnuts or pies ≤ 3 days/week, 8. eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies ≤ 3 days/week, 9. using active transportation going to and from school, 10. going to a sports or dancing club ≥ 2 days/week, 11. playing outside ≥ 1 hour/day, 12. spending screen time < 2 hours/day, and 13. sleep duration ≥ 9 hours/day; § Combination of 'fresh fruit' and '100% fruit juice'.

Table 5.7 Associations* between three risk behaviour scores and obesity in a subgroup of children without missing data†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Score categories	Countries											
	Bulgaria		Czech Republic		Lithuania		Portugal		Sweden		Total five countries	
	n	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)
Food-risk behaviour score												
0	52	1.00	64	1.00	85	1.00	248	1.00	756	1.00	1205	1.00
1	114	0.80 (0.34;1.86)	178	0.75 (0.27;2.07)	292	0.93 (0.43;2.00)	449	0.99 (0.66;1.50)	620	**1.75° (1.13;2.72)**	1653	1.20 (0.93;1.55)
2	288	0.87 0.41;1.83)	270	0.93 (0.36;2.40)	683	0.81 (0.40;1.67)	407	1.05 (0.69;1.60)	399	1.61 (0.98;2.63)	2047	1.21 (0.93;1.56)
3	359	0.92 (0.44;1.92)	231	0.69 (0.26;1.87)	671	1.05 (0.52;2.15)	155	1.10 (0.65;1.85)	106	1.68 (0.79;3.56)	1522	1.28 (0.97;1.69)
4	356	0.68 (0.32;1.44)	128	0.72 (0.25;2.14)	350	0.78 (0.36;1.68)	68	0.82 (0.39;1.71)	28	1.45 (0.32;6.50)	930	0.98 (0.72;1.35)
5	355	0.81 (0.38;1.70)	45	0.70 (0.18;2.75)	197	0.93 (0.41;2.12)	27	0.76 (0.25;2.33)	6	–	630	1.10 (0.78;1.55)
6	253	0.65 (0.30;1.44)	15	2.21 (0.47;10.53)	69	1.41 (0.55;3.63)	14	1.18 (0.31;4.51)	4	–	355	1.04 (0.70;1.56)
7	117	0.61 (0.25;1.48)	4	2.07 (0.16;27.49)	22	0.33 (0.04;2.76)	3	2.00 (0.17;23.69)	2	–	148	0.80 (0.45;1.43)
8	20	0.46 (0.09;2.38)	1	–	0	–	0	–	1	–	22	0.95 (0.27;3.39)

Physical activity-risk behaviour score												
0	70	1.00	130	1.00	102	1.00•	44	1.00	351	1.00••	697	1.00••
1	411	0.70 (0.36;1.36)	394	1.07 (0.49;2.34)	553	1.74 (0.67;4.53)	304	0.67 (0.31;1.45)	742	1.79 (0.90;3.54)	2404	1.21 (0.87;1.67)
2	948	0.77 (0.41;1.45)	306	1.67 (0.77;3.63)	1009	2.39 (0.94;6.05)	516	0.62 (0.29;1.31)	606	**2.75°° (1.40;5.41)**	3385	**1.47° (1.07;2.03)**
3	414	0.98 (0.51;1.88)	92	0.98 (0.35;2.78)	615	**3.02° (1.18;7.74)**	370	0.82 (0.38;1.76)	206	**3.03°° (1.40;6.57)**	1697	**1.79°°° (1.28;2.50)**
4	64	1.05 (0.44;2.49)	14	–	79	2.17 (0.67;7.01)	125	0.95 (0.41;2.18)	17	**7.19°° (1.72;30.02)**	299	**1.83°° (1.19;2.84)**
5	7	–	0	–	11	4.30 (0.70;26.29)	12	0.56 (0.10;3.05)	0	–	30	1.26 (0.41;3.85)
Health-risk behaviour score‡												
0–1	31	1.00	66	1.00	46	1.00	103	1.00	565	1.00••	811	1.00
2	81	0.88 (0.30;2.59)	136	0.62 (0.20;1.89)	163	1.32 (0.36;4.84)	205	0.86 (0.45;1.66)	510	1.16 (0.65;2.08)	1095	1.11 (0.78;1.58)
3	138	1.04 (0.38;2.84)	215	0.82 (0.30;2.22)	338	1.75 (0.51;5.98)	320	1.05 (0.58;1.92)	464	**2.34°° (1.38;3.96)**	1475	**1.64°° (1.18;2.27)**
4	247	0.84 (0.32;2.21)	208	1.14 (0.43;3.00)	502	1.49 (0.44;5.05)	309	1.23 (0.68;2.23)	238	**2.66°°° (1.47;4.81)**	1504	**1.64°° (1.17;2.29)**
5	316	1.00 (0.39;2.61)	153	0.89 (0.32;2.52)	509	1.97 (0.59;6.63)	219	1.13 (0.60;2.11)	98	1.26 (0.49;3.23)	1295	**1.68°° (1.19;2.37)**
6	297	0.70 (0.26;1.85)	97	0.62 (0.19;2.02)	419	1.65 (0.49;5.62)	107	1.66 (0.83;3.33)	33	**3.69° (1.26;10.82)**	953	**1.50° (1.04;2.16)**
7	342	0.75 (0.29;1.97)	35	1.42 (0.38;5.29)	232	1.99 (0.57;6.93)	72	0.98 (0.44;2.19)	8	3.58 (0.40;31.65)	689	**1.48° (1.01;2.18)**
8	263	0.98 (0.37;2.59)	18	0.64 (0.07;5.88)	115	1.82 (0.49;6.82)	23	0.73 (0.19;2.75)	4	–	423	**1.57° (1.03;2.41)**
9	144	0.58 (0.20;1.68)	5	1.64 (0.14;18.83)	32	3.47 (0.78;15.46)	10	–	1	–	192	1.13 (0.64;1.97)

Table 5.7 *(Contd.)*

Score categories	Countries											
	Bulgaria		Czech Republic		Lithuania		Portugal		Sweden		Total five countries	
	n	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)
10	48	1.08 (0.33;3.52)	2	–	10	–	2	–	1	–	63	1.40 (0.64;3.10)
11	6	0.72 (0.07;7.67)	1	–	3	–	1	–	0	–	11	**7.10°° (2.00;25.20)**
12	1	–	0	–	0	–	0	–	0	–	1	–
13	0	–	0	–	0	–	0	–	0	–	0	–

Abbreviations: –, sample size was 0 or none of the children in this score category were obese and thus the OR could not be estimated for this category; BMI/A, body mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.
Notes. Significance levels of ORs: ° $P < 0.05$ °° $P \leq 0.01$ °°° $P \leq 0.001$; Significant associations are shown in bold; Significant linear trend of ORs for the respective risk behaviour score (Likelihood ratio test): • $P < 0.01$ •• $P < 0.001$.
* All analyses were adjusted for the children's sex and age, children's residential urbanization grade, parental education and parental occupation and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or obese children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), who returned a filled out family record form, and who had no missing values on any of the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation. Obesity is defined as the proportion of children with a BMI/A value above +2 Z-scores relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ The reference category was not set as a health-risk score of 0 but 0–1, because only six Bulgarian, 15 Czech, seven Lithuanian, nine Portuguese and 160 Swedish children obtained a health-risk score of 0.

due to the younger age of the COSI children as it has been suggested elsewhere that skipping breakfast is more prevalent among older children[29].

Other identified European-wide studies included subnationally representative samples of children[30,31] or adolescents[32] or secondary datasets based on different measures[33]. Therefore comparisons of their data with ours are difficult.

We assessed the average number of less favourable behaviours present by assigning a risk score to each child. We could identify two Dutch studies that also summarized the number of behaviours children were engaged in by means of a risk score[34,35]. However, comparisons with their results were not possible because of the use of different and fewer behavioural indicators.

None of the six abovementioned European-wide studies[16,28,30–33] that have collected data on individual behaviours related to both nutrition and/or physical activity used the score approach. Instead, three[36–38] have performed cluster analysis to study interrelationships among multiple behaviours and to identify high-risk groups of children in Europe, whereby country representation varied in the different clusters[36] and not necessarily all less favourable behaviours occurred simultaneously in a cluster[36–38]. This has also been shown in country-specific studies that used similar food-related and/or physical activity-related behaviours[39–41]. COSI has been set up to monitor data by country and to make intercountry comparisons possible. We did not consider the available number of children with complete data on the 13 risk behaviours sufficient to find a reasonable amount of differentiable clusters by country that would be large enough to warrant strategic attention[42].

It is expected that children with excess body weight are more likely to be engaged in less favourable behaviours. This was the case in our study for two food-related risk behaviours: not having breakfast every day and eating 'foods like pizza, French fries (chips), hamburgers, sausages or meat pies' > 3 days/week (Table 5.6). But we also found the opposite to be true for three food-related risk behaviours of not eating fruit every day, eating 'foods like potato chips (crisps), corn chips, popcorn or peanuts' > 3 days/week and eating 'foods like biscuits, cakes, doughnuts or pies' > 3 days/week (Table 5.6), whereby children performing these three behaviours were less likely to be obese or overweight (Supplementary Table 5.5). A possible explanation for these results may be the cross-sectional nature of the COSI data and thus reverse causality has to be taken into account. Children with excess body weight may already have changed their eating patterns and therefore have truthfully answered the form according to the current situation and not according to what actually may have led to their overweight status.

Positive associations between skipping breakfast and excess weight have been also been reported by several other studies[34,43,44], while to our knowledge a negative association between low fruit intake and obesity or overweight in just a few[33]. We did not find relevant studies to compare with for the other two less favourable food-related behaviours (items (v)

and (vii)) for which we found statistically significant negative associations with obesity and overweight, and the second less favourable food-related behaviour (item (viii)) for which we found a statistically significant positive association with obesity. Concerning the five physical activity-related risk behaviours in our study, spending screen time ≥ 2 hours/day and playing outside < 1 hour/day were the only behaviours that were statistically significantly associated with higher odds of obesity. Positive associations between watching television and other screen activities and BMI have also been reported by several other studies[33,34,45].

It has been suggested that a combination of less favourable behaviours related to both nutrition and physical activity may have a possible synergetic effect that could lead to a multiplication of the risk of obesity or overweight[34,36,38–40]. In our study, we found for the total group of children in the five countries that a health-risk behaviour score of 3–8 or a score of 11 (thus a combination of three or more less favourable behaviours on both nutrition and physical activity), as well as a physical activity-risk behaviour score of 2–4, led to higher odds of obesity (Table 5.7). This was not shown for the food-risk behaviour score.

Several methodological issues of the present study need to be acknowledged. Its strengths include the availability of nationally representative samples of more than 10 000 children, the administration of the same COSI family form in five countries, which enabled the intercountry comparisons, as well as the standardized weight and height measurements[12]. However, the study also has some limitations.

The first set of concerns relates to the questionnaire used. For instance, the questions on the children's behaviours were adapted from the HBSC 2002 questionnaire[15] that has been validated among adolescents[46], but to our knowledge not among children within the COSI targeted age range of 6–9 years. Furthermore, in the COSI questions we used fewer answer categories than incorporated in the HBSC questionnaire, because the COSI family form was designed to give a rough indication of the prevalence of the children's health-risk behaviours and not for detailed analyses between risk behaviours and health outcomes. For instance, the COSI food frequency questionnaire (FFQ) uses four frequency categories for a usual week while the 2001/2002 HBSC uses seven[15]. In our questionnaire, we also did not collect data on portion sizes, which have been suggested to be positively associated with obesity[47].

A second set of concerns relates to filling in the questionnaire. For example, the data were reported by the parents (possibly together with their child). COSI was introduced to the parents as a European Childhood Growth Study with the aim to promote the health and well-being among primary-school children, the words overweight or obesity were not mentioned, and the children's height and weight measurement values were only provided to the parents upon request. Nevertheless, it might be that parents were aware of their child's weight status and that this could have influenced the report on their child's behaviours. Parents with overweight children are likely to over report more favourable behaviours and underreport less favourable behaviours[48,49], and parents who are concerned about their

child's weight status are more likely to limit child screen time, take steps to improve their child's diet or increase their child's physical activity[50]. In addition, we do not know to what extent the parents completed the form solely by themselves or together with their child. A validation study comparing the children's report with their parent's report on the children's energy intake using FFQ suggests that children (aged 8–11 years) are more accurate reporters than their parents, and that fathers are more accurate than mothers[51].

A third concern relates to the representativeness of the children in our analysis. One-third of the children included in the analysis had a missing value on any of the health-risk behaviours or on children's residential urbanization grade, parental education or parental occupation. Compared with the group of children with missing values (n = 5126), the subgroup of children without any missing values (n = 10 517) included 14.2% fewer children whose parents had a low educational level, 2.3% fewer children whose parents were both unemployed and 5.6% more children who lived in the urban area. In addition, the subgroup contained fewer children for five less favourable behaviours (range absolute difference: –1% to –8%) and more children for four less favourable behaviours (range absolute difference: +2% to +4%). While these statistically significant, although relatively small, group differences may have influenced the results of the multivariable analyses, it is likely that the missing data were at random and that the effect estimates were not biased[52].

A final limitation relates to the fact that only five out of 13 countries administered the voluntary family form in COSI Round 2007/2008. This allows us to make some intercountry comparisons, but obviously the number of countries is too small to identify groups of countries with similar patterns of health-risk behaviours like we could do with the data on the children's weight and height measurements[14] and with the data on the school nutrition environment[53].

CONCLUSION

In conclusion, despite a categorization of behaviours that was based on international health recommendations, only four out of 13 health-risk behaviours were found to be positively associated with obesity and three were even found to be negatively associated with obesity or overweight. A combination of health-risk behaviours, on the other hand, showed more consistent findings and all in the same direction. The significant positive associations found between the physical activity-risk scores and obesity, as well as between the health-risk scores and obesity, underline the importance of, in particular, promoting physical activity-related and discouraging sedentary behaviours among schoolchildren in the context of obesity preventive interventions.

Given the strengths and limitations, the data collected in the present study can be considered valuable at the country level to indicate the level of behavioural health risks on

nutrition and physical activity among primary-school children. The results show that with the present data it is possible to investigate variations in behaviours across countries, but to identify sub-European differences in behavioural health risks among schoolchildren, data from more countries should be collected. COSI includes repeated data collection rounds in 2–3-year intervals, whereby with each round more countries are expected to join[12]. It is thus envisaged that future rounds may provide more explanatory suggestions for the overweight north–south gradient found in other COSI analyses, whereby the highest prevalence was found in southern European countries[14,54].

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

TW conceptualized and drafted the manuscript and conducted all analyses; JvR made substantial contributions to the conception and drafts of the manuscript, as well as interpretation of the results; AY, AS and MK were involved in critically reviewing a draft of the manuscript and contributed with data collection and data cleaning; VD, AP, AR and JB contributed with data collection and data cleaning. All authors contributed to and approved the final manuscript.

DISCLAIMER

TW and JB are staff members of the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions or the stated policy of the World Health Organization.

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ETHICS OF HUMAN SUBJECT PARTICIPATION

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by local ethical committees. Parents were fully informed about the anthropometric measurements, and their written informed consent was obtained using either an active or passive approach. Children's consent was always obtained prior to the measurements, and confidentiality of all collected and archived data was ensured.

In Bulgaria ethics approval had to be sought from the Medical Ethical Committee of the former National Center of Public Health Protection and permission to be granted before the start of the survey. The documents that needed to be sent to the Committee were: the application request, the study design and protocol with questionnaires, the list of participants and the parent's informed consent letter (passive approach). Further, three levels of permission had to be asked for the conduct of the study: firstly for the access to the schools from the Ministry of Education, then this permission letter and further information were provided to the Regional Inspectorates of Education, and thirdly the administration (director) of each school had to be asked for approval. A teacher was not permitted to participate if a director had not agreed.

In the Czech Republic the study was agreed by the Institutional Ethical Committee of the Institute of Endocrinology in Prague after having received the detailed design of the study in

2008. The approval letter is archived in the Ethical Committee of the Institute of Endocrinology. Paediatricians who perform the obligatory 7-year preventive check-up at paediatric clinics informed parents about the study and the measuring procedures, and gave them an informed consent form to sign before their child was measured for the study. Children were also asked to express their agreement to participate in the study before being included.

Ethics approval for the 'Growth surveillance study of Lithuanian children' was sought in January 2008 from the Lithuanian Bioethics Committee. Permission was granted in March 2008. The documents that needed to be sent to the Committee as part of the ethics approval procedures were: the application requesting permission to perform the biomedical survey, a filled out application form for biomedical research, the study protocol, questionnaires and information on the confidentiality of personal information, a filled out ethical evaluation form for biomedical research, the curriculum vitae of the applicant and the applicant's criminal history. In addition, approval to implement the study in schools was sought from the Lithuanian Ministry of Education and Science and the education departments in local municipalities.

In Portugal, the Directorate-General of Health in Lisbon sought ethics approval from the Portuguese Data Protection Authority. All methodological aspects, particularly the anthropometric measurements of the children and a precise explanation of the informed parental consent and children's consent on the day of the measurements, were included in the application. The approval letter was sent to the Directorate-General of Health and archived there.

In Sweden, ethics approval was sought in 2008 from the Regional Ethics Committee in Gothenburg for data collection in the southern and western parts of Sweden and from the Regional Ethics Committee in Stockholm for data collection in the northern and eastern parts of Sweden. The procedures to follow were exactly the same for both regional committees and one form about the procedures was completed at each site. This included a full description of the project, a research plan including research questions to be answered, all details about the measurements to be made, the data collection procedures and secure data handling. It also included letters informing parents and teachers about the project, parental consent and information to children. Questions regarding possible risk/benefit to the children were answered as well as how the data would be coded on individual level and handled according to Swedish law. Approval from the Stockholm committee was granted while the Gothenburg committee stated that no approval was needed.

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Supplementary Table 5.1 Characteristics of parental education, parental occupation and children's residential urbanization grade of the total study group*, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Characteristics	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
	%				
Maternal education (total *n*)†	3165	1587	3977	2931	3554
Primary school	23.8	9.2	10.5	23.7	5.9
Secondary school	43.9	64.5	38.9	59.8	53.1
Undergraduate/bachelor's degree	12.3	8.4	40.3	14.4	34.1
Master's degree or higher	20.1	18.0	10.4	2.1	7.0
Paternal education (total *n*)†	3095	1549	3625	2869	3365
Primary school	22.8	9.6	10.8	29.3	9.4
Secondary school	55.5	62.6	46.5	59.2	59.0
Undergraduate/bachelor's degree	7.0	7.7	34.8	9.9	23.6
Master's degree or higher	14.6	20.1	7.9	1.6	7.9
Parental education (total *n*)†	3062	1546	3592	2844	3322
Both parents low‡	63.2	62.0	37.9	80.2	49.3
Maternal occupation (total *n*)†	3159	1566	3974	2920	3353
Government employed	19.4	23.4	31.3	60.8§	39.8
Non-government employed	40.4	37.6	37.8	–	39.3
Self-employed	7.5	8.8	5.2	10.9	7.2
Student	0.7	0.1	2.1	0.8	6.2
Homemaker	19.2	25.7	18.6	18.4	2.5
Unemployed, able to work	11.8	3.8	3.3	7.9	2.0
Unemployed, unable to work	0.6	0.6	1.7	0.8	1.4
Retired	0.4	0.1	0.0	0.4	1.7
Paternal occupation (total *n*)†	3042	1516	3551	2854	3228
Government employed	19.8	18.9	23.3	72.3§	18.4
Non-government employed	52.2	49.9	53.3	–	58.8
Self-employed	14.3	27.6	15.3	21.3	18.8
Student	0.1	0.0	0.2	0.0	1.2
Homemaker	0.3	0.3	1.3	0.3	0.2
Unemployed, able to work	11.6	2.2	5.0	4.2	0.9
Unemployed, unable to work	1.0	0.8	1.7	1.1	0.7
Retired	0.8	0.4	0.0	0.8	1.0
Parental occupation (total *n*)†	3013	1497	3511	2806	3106
Both parents unemployed	10.4	2.3	3.6	3.0	2.0

Supplementary Table 5.1 *(Contd.)*

Characteristics	Countries				
	Bulgaria %	Czech Republic	Lithuania	Portugal	Sweden
Children's residential urbanization grade (total *n*)†	3267	1556	4084	3026	3633
Urban	78.8	47.8	32.8	66.4	29.2
Semi-urban	0.1	23.5	40.9	20.2	15.5
Rural	21.2	28.7	26.3	13.5	55.3

Abbreviations: –, not applied as answer option; BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative.

* Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), and who returned a filled out family record form; † Statistically significant difference of proportions across the countries (chi-squared test; $P < 0.001$); ‡ The highest educational level of both parents is either primary or secondary school; § This value included 'government-employed' and 'non-government employed'.

Supplementary Table 5.2 Proportion (%) of consumption frequencies of breakfast and eight food items over a typical or usual week for the total study group*, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Consumption frequency	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
	%				
Breakfast (total *n*)†	3246	1604	4036	3002	3626
Every day	78.9	75.7	67.5	95.6	94.4
4–6 days	12.2	10.8	7.9	2.0	3.8
1–3 days	7.5	11.2	14.3	1.8	1.6
Never	1.5	2.4	10.3	0.6	0.2
Fresh fruit (total *n*)†	3202	1590	4008	2958	3608
Every day	27.1	52.0	31.4	61.5	66.7
4–6 days	29.5	32.3	28.4	18.1	19.7
1–3 days	41.5	14.8	39.4	18.4	12.0
Never	2.0	0.9	0.8	2.0	1.8
100% fruit juice (total *n*)†	3145	1562	3914	2856	3585
Every day	18.7	5.1	13.8	13.8	11.6
4–6 days	19.5	9.2	19.8	13.3	13.8
1–3 days	48.9	61.1	63.0	50.8	53.4
Never	13.0	24.6	3.4	22.1	21.3
Vegetables (excluding potatoes) (total *n*)†	3174	1582	3992	2890	3599
Every day	23.6	28.3	23.3	39.5	53.4
4–6 days	36.0	36.4	32.1	25.4	29.5
1–3 days	38.2	33.3	42.7	31.6	15.4
Never	2.2	2.0	1.9	3.5	1.7
Soft drinks containing sugar (total *n*)†	3190	1563	3955	2852	3597
Every day	21.9	25.3	9.4	9.9	1.5
4–6 days	16.7	21.2	10.1	10.3	7.0
1–3 days	40.8	39.8	65.7	46.5	78.5
Never	20.7	13.7	14.8	33.3	13.0
Foods like potato chips (crisps), corn chips, popcorn or peanuts (total *n*)†	3224	1570	3989	2901	3608
Every day	21.3	1.4	3.0	1.6	0.1
4–6 days	25.2	2.9	6.6	3.9	1.0
1–3 days	49.8	69.0	80.8	60.9	83.7
Never	3.7	26.7	9.5	33.6	15.2

Supplementary Table 5.2 (*Contd.)*

Consumption frequency	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
	%				
Foods like candy bars or chocolate (total *n*)†	3237	1599	4010	2897	3616
Every day	33.6	6.3	18.3	2.7	0.3
4–6 days	29.8	18.1	25.7	9.0	2.0
1–3 days	35.3	71.0	55.6	73.2	93.0
Never	1.4	4.6	0.5	15.1	4.8
Foods like biscuits, cakes, doughnuts or pies (total *n*)†	3218	1593	3929	2929	3608
Every day	20.5	5.6	12.6	8.4	0.6
4–6 days	25.9	18.6	20.7	17.3	5.8
1–3 days	49.2	71.6	65.6	65.6	83.3
Never	4.4	4.2	1.1	8.6	10.4
Foods like pizza, French fries (chips), hamburgers, sausages or meat pies (total *n*)†	3238	1578	3982	2864	3615
Every day	17.1	0.5	1.6	1.3	0.2
4–6 days	22.3	1.7	5.8	5.3	1.8
1–3 days	56.7	68.0	81.2	72.4	90.4
Never	4.0	29.9	11.5	21.0	7.6

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative.
* Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range ($\geq -5 - \leq +5$), and who returned a filled out family record form; † Statistically significant difference of proportions of the four answer options across the countries (chi-squared test; $P < 0.001$).

Supplementary Table 5.3 Proportion (%) of items related to physical activity and screen time for the total study group*, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Items	Countries				
	Bulgaria %	Czech Republic	Lithuania	Portugal	Sweden
Physical activity					
Usual transport going to school (total *n*)†	3255	1581	4069	2876	3609
School bus	8.2	5.6	7.3	15.8	9.3
Public transport	3.5	7.0	5.9	2.2	1.0
Car	28.6	32.5	38.3	56.2	39.5
Bicycle	0.9	1.3	0.3	0.3	9.6
Walking	58.7	52.1	48.0	25.0	32.7
Other‡	0.0	1.6	0.2	0.5	7.9
Usual transport coming from school (total *n*)†	3230	1522	4006	2816	3554
School bus	8.1	4.1	7.1	19.6	7.0
Public transport	4.1	7.0	7.9	1.9	1.0
Car	18.1	28.2	24.8	46.8	39.9
Bicycle	0.8	1.1	0.2	0.3	9.7
Walking	68.9	57.5	60.0	30.9	34.2
Other‡	0.0	2.2	0.1	0.5	8.2
Membership sports or dancing club (total *n*)†	3216	1561	3943	2939	3608
Yes	25.4	59.7	43.2	41.2	77.5
Frequency sports or dancing club weekly (total *n*)†,§	793	929	1703	1200	2797
0 days	0.0	0.7	0.0	0.3	0.0
1 day	15.5	39.4	29.1	27.8	34.0
2 days	53.7	36.7	42.4	50.8	38.2
3 days	20.2	16.5	20.1	14.4	20.5
4 days	5.2	5.1	5.8	4.9	5.7
5 days	4.7	1.4	2.4	1.5	1.4
6 days	0.3	0.1	0.2	0.2	0.3
7 days	0.5	0.2	0.1	0.1	0.0

Supplementary Table 5.3 (*Contd.*)

Items	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
	%				
Playing outside on a weekday (total *n*)†	3236	1611	4040	2950	3610
Never	1.3	1.2	3.1	19.1	0.4
< 1 hour/day	5.8	5.8	6.4	23.9	8.2
About 1 hour/day	19.8	28.4	20.4	28.5	25.9
About 2 hours/day	42.7	43.0	37.2	20.8	39.7
About 3 or more hours/day	30.4	21.7	32.9	7.7	25.8
Playing outside on a weekend day (total *n*)†	3215	1589	3958	2908	3564
Never	0.4	0.1	0.5	6.6	0.1
< 1 hour/day	1.1	0.4	0.7	5.6	1.7
About 1 hour/day	1.4	3.0	3.9	12.7	8.3
About 2 hours/day	14.6	17.7	12.0	24.0	28.3
About 3 or more hours/day	82.5	78.9	82.9	51.0	61.6
Screen time					
Using a computer on a weekday (total *n*)†	3008	1566	4024	2676	3613
Never	38.0	41.6	33.7	49.6	23.5
< 1 hour/day	26.5	34.5	19.2	38.0	54.8
About 1 hour/day	24.2	19.6	31.7	9.9	17.9
About 2 hours/day	9.4	4.0	12.7	2.2	3.6
About 3 or more hours/day	2.0	0.3	2.7	0.3	0.3
Using a computer on a weekend day (total *n*)†	3001	1556	3951	2672	3603
Never	33.4	27.8	25.8	28.7	11.6
< 1 hour/day	19.2	35.5	12.8	32.5	43.8
About 1 hour/day	11.8	21.6	26.7	21.6	27.0
About 2 hours/day	26.2	12.9	24.8	13.5	13.9
About 3 or more hours/day	9.4	2.1	9.9	3.7	3.7

Supplementary Table 5.3 (*Contd.*)

Items	Countries				
	Bulgaria	Czech Republic	Lithuania	Portugal	Sweden
	%				
Watching television on a weekday (total *n*)†	3248	1605	4071	2985	3616
Never	1.5	4.2	1.3	3.5	1.5
< 1 hour/day	13.7	35.6	7.8	36.6	26.1
About 1 hour/day	30.6	40.8	35.6	34.6	49.5
About 2 hours/day	37.3	17.3	40.7	21.4	20.6
About 3 or more hours/day	16.8	2.1	14.6	4.1	2.3
Watching television on a weekend day (total *n*)†	3235	1600	4010	2965	3606
Never	1.7	1.6	1.3	0.7	0.2
< 1 hour/day	6.4	10.4	2.8	8.3	5.6
About 1 hour/day	6.4	27.8	15.5	21.1	20.2
About 2 hours/day	39.3	46.4	39.7	40.8	52.9
About 3 or more hours/day	46.2	13.8	40.8	29.0	21.1

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative.
* Children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), and who returned a filled out family record form; † Statistically significant difference of proportions of the answer options across the countries (chi-squared test; $P < 0.001$); ‡ Other options for transport written down on the form were taxi, motorcycle, kick scooter or a combination of the listed options; § This question was only answered by the children who were members of a sports or dancing club.

Supplementary Table 5.4 Bivariate associations* between 13 health-risk behaviours and overweight in the total study group†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Health-risk behaviour	Countries					
	Bulgaria OR (95% CI)	Czech Republic	Lithuania	Portugal	Sweden	Total five countries
Breakfast and food consumption frequency						
1‡ Having breakfast < 7 days/week	1.11 (0.91;1.34)	**1.56°°° (1.19;2.04)**	**1.39°°° (1.19;1.62)**	1.38 (0.96;1.98)	1.25 (0.91;1.73)	**1.31°°° (1.18;1.45)**
2‡ Eating fruit§ < 7 days/week	0.93 (0.79;1.10)	1.05 (0.83;1.34)	**0.83° (0.72;0.97)**	0.97 (0.83;1.14)	0.94 (0.80;1.12)	0.93 (0.86;1.00)
3‡ Eating vegetables (excluding potatoes) < 7 days/week	**0.74°°° (0.61;0.89)**	1.08 (0.82;1.42)	1.00 (0.84;1.19)	0.98 (0.83;1.15)	1.14 (0.97;1.33)	0.98 (0.90;1.06)
4‡ Drinking soft drinks containing sugar > 3 days/week	0.92 (0.78;1.09)	0.91 (0.71;1.17)	0.97 (0.81;1.17)	**1.23° (1.01;1.48)**	1.16 (0.88;1.52)	1.00 (0.91;1.10)
5‡ Eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week	**0.79°° (0.67;0.92)**	1.01 (0.55;1.86)	**0.72° (0.55;0.94)**	0.90 (0.64;1.28)	0.49 (0.19;1.26)	**0.79°°° (0.70;0.89)**
6‡ Eating foods like candy bars or chocolate > 3 days/week	0.97 (0.82;1.14)	**0.73° (0.54;0.99)**	0.90 (0.77;1.04)	0.94 (0.74;1.19)	1.06 (0.63;1.79)	**0.91° (0.83;1.00)**
7‡ Eating foods like biscuits, cakes, doughnuts or pies > 3 days/week	**0.74°°° (0.63;0.87)**	**0.58°°° (0.42;0.79)**	**0.81°° (0.69;0.95)**	0.86 (0.72;1.03)	0.84 (0.60;1.17)	**0.78°°° (0.72;0.85)**
8‡ Eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies > 3 days/week	0.85 (0.72;1.01)	1.40 (0.64;3.04)	0.96 (0.72;1.29)	0.87 (0.63;1.19)	1.25 (0.74;2.13)	0.89 (0.79;1.01)
Physical activity						
9‡ Using inactive transportation going to and from school	1.07 (0.88;1.28)	0.95 (0.73;1.24)	1.13 (0.96;1.33)	1.02 (0.84;1.24)	1.10 (0.92;1.32)	1.07 (0.99;1.17)
10‡ Going to a sports or dancing club < 2 days/week	0.93 (0.76;1.13)	0.85 (0.66;1.09)	1.15 (0.97;1.36)	1.01 (0.85;1.20)	1.08 (0.91;1.27)	1.02 (0.94;1.11)
11‡ Playing outside < 1 hour/day	1.35 (0.95;1.93)	**0.51° (0.26;0.99)**	1.27 (0.97;1.67)	1.02 (0.86;1.20)	1.11 (0.83;1.49)	1.08 (0.96;1.22)

Screen time and sleep duration						
12‡ Spending screen time ≥ 2 hours/day	**1.23° (1.02;1.49)**	**1.52°°° (1.18;1.97)**	**1.29°° (1.08;1.54)**	**1.21° (1.02;1.44)**	**1.28°° (1.09;1.50)**	**1.28°°° (1.18;1.38)**
13‡ Sleep duration < 9 hours/day	0.88 (0.71;1.08)	1.09 (0.65;1.82)	1.05 (0.83;1.31)	1.08 (0.86;1.35)	**1.67° (1.12;2.50)**	1.04 (0.92;1.17)

Abbreviations: BMI/A, body mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.

Notes. Significance levels of ORs: ° $P < 0.05$ °° $P < 0.01$ °°° $P < 0.001$; Significant associations are shown in bold.

* All bivariate analyses were adjusted for the children's sex and age and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or overweight children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), and who returned a filled out family record form. Overweight is defined as the proportion of children with a BMI/A value above +1 Z-score relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ Reference categories for each health-risk behaviour were: 1. having breakfast every day, 2. eating fruit every day, 3. eating vegetables (excluding potatoes) every day, 4. drinking soft drinks containing sugar ≤ 3 days/week, 5. eating foods like potato chips (crisps), corn chips, popcorn or peanuts ≤ 3 days/week, 6. eating foods like candy bars or chocolate ≤ 3 days/week, 7. eating foods like biscuits, cakes, doughnuts or pies ≤ 3 days/week, 8. eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies ≤ 3 days/week, 9. using active transportation going to and from school, 10. going to a sports or dancing club ≥ 2 days/week, 11. playing outside ≥ 1 hour/day, 12. spending screen time < 2 hours/day, and 13. sleep duration ≥ 9 hours/day; § Combination of 'fresh fruit' and '100% fruit juice'.

Supplementary Table 5.5 Multivariable associations* between 13 health-risk behaviours and overweight in a subgroup of children without missing data†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Health-risk behaviour		Countries					
		Bulgaria (*n* = 2311)	**Czech Republic (*n* = 1077)**	**Lithuania (*n* = 2817)**	**Portugal (*n* = 1805)**	**Sweden (*n* = 2315)**	**Total five countries (*n* = 10 325)**
		OR (95% CI)					
Breakfast and food consumption frequency							
1‡	Having breakfast < 7 days/week	**1.28° (1.01;1.61)**	**1.53° (1.08;2.18)**	**1.43°°° (1.19;1.72)**	1.55 (0.97;2.46)	1.46 (0.94;2.27)	**1.39°°° (1.23;1.57)**
2‡	Eating fruit§ < 7 days/week	0.98 (0.80;1.21)	1.15 (0.81;1.62)	**0.80° (0.66;0.97)**	0.87 (0.70;1.08)	0.89 (0.71;1.12)	**0.90° (0.81;0.99)**
3‡	Eating vegetables (excluding potatoes) < 7 days/week	**0.75° (0.59;0.94)**	0.96 (0.65;1.42)	1.04 (0.83;1.30)	1.02 (0.83;1.26)	1.12 (0.91;1.38)	1.00 (0.90;1.11)
4‡	Drinking soft drinks containing sugar > 3 days/week	1.09 (0.88;1.34)	0.84 (0.61;1.15)	1.10 (0.87;1.40)	**1.36° (1.05;1.76)**	1.01 (0.70;1.48)	1.08 (0.96;1.21)
5‡	Eating foods like potato chips (crisps), corn chips, popcorn or peanuts > 3 days/week	0.84 (0.68;1.03)	1.22 (0.53;2.81)	**0.67° (0.45;0.98)**	1.24 (0.67;2.31)	0.48 (0.15;1.60)	**0.81° (0.69;0.96)**
6‡	Eating foods like candy bars or chocolate > 3 days/week	1.05 (0.85;1.30)	0.81 (0.54;1.21)	1.03 (0.85;1.25)	0.72 (0.50;1.05)	1.15 (0.54;2.46)	0.98 (0.87;1.10)
7‡	Eating foods like biscuits, cakes, doughnuts or pies > 3 days/week	**0.76° (0.61;0.95)**	**0.61° (0.40;0.93)**	**0.79° (0.64;0.97)**	0.87 (0.68;1.11)	0.99 (0.65;1.51)	**0.80°°° (0.72;0.90)**
8‡	Eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies > 3 days/week	0.99 (0.79;1.24)	1.25 (0.43;3.67)	1.42 (0.97;2.10)	1.18 (0.68;2.05)	1.54 (0.74;3.22)	1.08 (0.91;1.28)
Physical activity							
9‡	Using inactive transportation going to and from school	1.12 (0.90;1.38)	0.85 (0.61;1.18)	1.08 (0.89;1.31)	1.03 (0.80;1.32)	1.02 (0.82;1.26)	1.06 (0.96;1.18)
10‡	Going to a sports or dancing club < 2 days/week	1.10 (0.87;1.38)	0.80 (0.58;1.10)	**1.25° (1.03;1.52)**	1.05 (0.84;1.31)	0.99 (0.81;1.22)	1.06 (0.96;1.17)
11‡	Playing outside < 1 hour/day	1.26 (0.83;1.91)	0.46 (0.19;1.10)	1.28 (0.94;1.73)	0.99 (0.81;1.22)	0.84 (0.56;1.28)	1.03 (0.90;1.19)

Screen time and sleep duration						
12‡ Spending screen time ≥ 2 hours/day	**1.29° (1.04;1.59)**	**1.64°° (1.18;2.27)**	**1.33°° (1.08;1.64)**	**1.26° (1.02;1.56)**	**1.25° (1.01;1.53)**	**1.33°°° (1.20;1.46)**
13‡ Sleep duration < 9 hours/day	0.99 (0.78;1.26)	0.66 (0.32;1.34)	0.97 (0.74;1.27)	0.90 (0.67;1.22)	1.58 (0.94;2.65)	1.00 (0.86;1.15)

Abbreviations: BMI/A, body mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.

Notes. Significance levels of ORs: ° $P < 0.05$ °° $P < 0.01$ °°° $P < 0.001$; Significant associations are shown in bold.

* All multivariable analyses were adjusted for the children's sex and age, included all 13 health-risk behaviours simultaneously, as well as children's residential urbanization grade, parental education and parental occupation and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or overweight children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), who returned a filled out family record form, and who had no missing values on any of the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation. Overweight is defined as the proportion of children with a BMI/A value above +1 Z-score relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ Reference categories for each health-risk behaviour were: 1. having breakfast every day, 2. eating fruit every day, 3. eating vegetables (excluding potatoes) every day, 4. drinking soft drinks containing sugar ≤ 3 days/week, 5. eating foods like potato chips (crisps), corn chips, popcorn or peanuts ≤ 3 days/week, 6. eating foods like candy bars or chocolate ≤ 3 days/week, 7. eating foods like biscuits, cakes, doughnuts or pies ≤ 3 days/week, 8. eating foods like pizza, French fries (chips), hamburgers, sausages or meat pies ≤ 3 days/week, 9. using active transportation going to and from school, 10. going to a sports or dancing club ≥ 2 days/week, 11. playing outside ≥ 1 hour/day, 12. spending screen time < 2 hours/day, and 13. sleep duration ≥ 9 hours/day; § Combination of 'fresh fruit' and '100% fruit juice'.

Supplementary Table 5.6 Associations* between three risk behaviour scores and overweight in a subgroup of children without missing data†, by country: nationally representative samples of 6–9-year-olds, COSI Round 1 (2007/2008)

Score categories	Countries											
	Bulgaria		Czech Republic		Lithuania		Portugal		Sweden		Total five countries	
	n	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)	*n*	OR (95% CI)
Food-risk behaviour score												
0	67	1.00	77	1.00	100	1.00	328	1.00	907	1.00	1479	1.00
1	136	0.71 (0.38;1.33)	209	0.78 (0.42;1.45)	350	1.06 (0.63;1.78)	580	0.93 (0.70;1.24)	750	1.20 (0.95;1.51)	2025	1.06 (0.90;1.24)
2	353	0.84 (0.48;1.46)	304	0.70 (0.38;1.26)	800	0.90 (0.56;1.47)	537	1.03 (0.77;1.38)	478	1.12 (0.86;1.47)	2472	1.04 (0.88;1.21)
3	436	0.84 (0.49;1.45)	266	0.67 (0.37;1.24)	807	1.14 (0.70;1.85)	209	1.12 (0.78;1.62)	125	1.06 (0.67;1.67)	1843	1.12 (0.94;1.34)
4	439	0.77 (0.45;1.34)	145	0.62 (0.32;1.23)	429	1.09 (0.66;1.81)	97	1.14 (0.71;1.83)	37	1.56 (0.75;3.25)	1147	1.07 (0.88;1.31)
5	421	0.73 (0.42;1.27)	54	0.80 (0.35;1.85)	224	0.87 (0.50;1.52)	34	0.78 (0.36;1.68)	11	3.21 (0.95;10.82)	744	0.96 (0.76;1.20)
6	297	0.64 (0.36;1.15)	16	0.88 (0.25;3.12)	82	1,28 (0.66;2.49)	16	0.70 (0.23;2.12)	4	–	415	0.89 (0.68;1.18)
7	140	0.67 (0.35;1.27)	5	1.52 (0.22;10.24)	25	0.59 (0.18;1.91)	4	1.72 (0.23;12.88)	2	–	176	0.84 (0.58;1.24)
8	22	0.40 (0.12;1.37)	1	–	0	–	0	–	1	–	24	0.64 (0.23;1.76)
Physical activity-risk behaviour score												
0	88	1.00	154	1.00	116	1.00•	53	1.00	407	1.00	818	1.00••
1	487	0.68 (0.41;1.12)	448	0.82 (0.52;1.29)	654	1.50 (0.89;2.54)	402	1.08 (0.59;1.99)	912	**1.49° (1.10;2.03)**	2903	1.19 (0.98;1.44)
2	1128	0.75 (0.46;1.20)	352	1.03 (0.65;1.64)	1206	**1.80° (1.08;3.00)**	679	1.04 (0.57;1.88)	739	**1.62°° (1.18;2.22)**	4104	**1.30°° (1.07;1.57)**
3	523	1.03 (0.63;1.68)	106	0.82 (0.44;1.53)	726	**1.94° (1.15;3.27)**	496	1.24 (0.68;2.27)	235	1.25 (0.82;1.90)	2086	**1.46°°° (1.19;1.79)**
4	78	0.97 (0.50;1.89)	17	0.76 (0.20;2.82)	102	**2.26° (1.18;4.34)**	160	1.17 (0.61;2.27)	22	**2.73° (1.09;6.89)**	379	**1.55°° (1.17;2.05)**
5	7	–	0	–	13	2.14 (0.59;7.70)	15	0.87 (0.25;2.97)	0	–	35	0.95 (0.43;2.10)

Health-risk behaviour score‡												
0–1	37	1.00	84	1.00	51	1.00	134	1.00	674	1.00	980	1.00
2	102	1.10 (0.48;2.50)	159	0.59 (0.31;1.09)	192	1.55 (0.67;3.55)	269	1.00 (0.64;1.55)	631	1.20 (0.92;1.57)	1353	1.11 (0.91;1.35)
3	170	1.17 (0.54;2.54)	243	0.53 (0.29;0.94)	406	1.90 (0.87;4.19)	411	1.02 (0.68;1.55)	548	1.19 (0.90;1.58)	1778	1.17 (0.97;1.42)
4	303	1.03 (0.49;2.19)	232	0.58 (0.32;1.03)	594	1.72 (0.79;3.75)	417	1.24 (0.82;1.87)	286	1.35 (0.97;1.88)	1832	**1.22° (1.00;1.49)**
5	373	1.00 (0.48;2.11)	175	0.56 (0.31;1.04)	611	2.03 (0.93;4.42)	292	1.19 (0.77;1.84)	115	0.93 (0.56;1.53)	1566	1.23 (1.00;1.50)
6	361	0.93 (0.44;1.97)	109	0.44 (0.22;0.89)	495	1.79 (0.81;3.92)	141	1.39 (0.84;2.29)	41	1.74 (0.87;3.49)	1147	1.17 (0.94;1.46)
7	415	0.96 (0.46;2.02)	43	0.92 (0.40;2.10)	277	2.04 (0.91;4.58)	93	1.02 (0.58;1.79)	12	3.01 (0.92;9.81)	840	1.22 (0.96;1.54)
8	306	0.98 (0.46;2.08)	21	0.53 (0.16;1.77)	134	1.78 (0.75;4.19)	32	1.12 (0.49;2.53)	6	1.83 (0.32;10.43)	499	1.13 (0.86;1.48)
9	179	0.98 (0.44;2.16)	8	2.07 (0.47;9.14)	40	**3.14° (1.15;8.56)**	11	0.17 (0.02;1.38)	1	–	239	1.19 (0.84;1.67)
10	58	1.16 (0.47;2.89)	2	–	14	2.29 (0.57;9.26)	4	1.84 (0.24;14.07)	1	–	79	1.32 (0.78;2.21)
11	6	0.37 (0.04;3.71)	1	–	3	9.75 (0.78;122.42)	1	–	0	–	11	2.29 (0.68;7.74)
12	1	–	0	–	0	–	0	–	0	–	1	–
13	0	–	0	–	0	–	0	–	0	–	0	–

Abbreviations: –, sample size was 0 or none of the children in this score category were overweight and thus the OR could not be estimated for this category; BMI/A, body mass index-for-age; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; PSU, primary sampling unit; WHO, World Health Organization.
Notes. Significance levels of ORs: ° $P < 0.05$ °° $P \leq 0.01$ °°° $P \leq 0.001$; Significant associations are shown in bold; Significant linear trend of ORs for the respective risk behaviour score (Likelihood ratio test): • $P < 0.01$ •• $P < 0.001$.

* All analyses were adjusted for the children's sex and age, children's residential urbanization grade, parental education and parental occupation and included random effects for the PSU. The analyses for the five countries together also included random effects for country; † Normal weight or overweight children with complete information on sex, whose age was between six and nine years old, whose weight and height were measured, whose BMI/A Z-score was within the normal range (≥ –5 – ≤ +5), who returned a filled out family record form, and who had no missing values on any of the 13 health-risk behaviours, children's residential urbanization grade, parental education and parental occupation. Overweight is defined as the proportion of children with a BMI/A value above +1 Z-score relative to the 2007 WHO growth reference median[25] and was compared against normal weight children (BMI/A value ≥ –2 Z-scores and ≤ +1 Z-score); ‡ The reference category was not set as a health-risk score of 0 but 0–1, because only eight Bulgarian, 18 Czech, seven Lithuanian, 10 Portuguese and 183 Swedish children obtained a health-risk score of 0.

6

WHO European Childhood Obesity Surveillance Initiative: impact of type of clothing worn during anthropometric measurements and timing of the survey on weight and body mass index outcome measures in 6–9-year-old children

Submitted
(With kind permission from the WHO Regional Office for Europe)

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ABSTRACT

Background: The World Health Organization European Childhood Obesity Surveillance Initiative (COSI) conducted examinations in 6–9-year-old children from 16 countries in the first two rounds of data collection. Allowing participating countries to adhere to their local legal requirements or adapt to other circumstances required developing a flexible protocol for anthropometric procedures.

Objectives: 1) Review intercountry variation in types of clothing worn by children during weight and height measurements, clothes weight adjustments applied, timing of the survey and duration of data collection; 2) assess the impact of the observed variation in these practices on the children's weight or body mass index (BMI) outcome measures.

Results: The relative difference between countries' unadjusted and clothes-adjusted prevalence estimates for overweight was 0.3–11.5%; this figure was 1.4–33.3% for BMI-for-age Z-score values. Monthly fluctuations in mean BMI-for-age Z-score values did not show a systematic seasonal effect. The majority of the monthly BMI-for-age Z-score values did not differ statistically within a country; only 1–3 monthly values were statistically different within some countries.

Conclusions: The findings of the present study suggest that the built-in flexibility in the COSI protocol concerning the data collection practices addressed in the paper can be kept and thus do not necessitate a revision of the COSI protocol.

INTRODUCTION

In 2013, 42 million children under five years old were overweight or obese, and in 2014, more than 1.9 billion adults aged 18 years and older were overweight or obese, according to the World Health Organization's (WHO) global estimates[1]. Halting the rise in the proportion of overweight children, adolescents and adults is one of the nine targets of the global monitoring framework on noncommunicable diseases[2]. In order to monitor the magnitude of this public health problem at the population level, as well as to interpret and compare prevalence estimates of overweight and obesity across countries in a meaningful way, valid anthropometric measurements, such as body weight and height, are crucial[3]. For example, the choice and validation of equipment, adherence to measurement protocols and level of training among field staff are critical aspects that apply to all settings in which these measures are taken and used[4].

The WHO European Childhood Obesity Surveillance Initiative (COSI) was established in 2006 with the aim to set up a harmonized surveillance system across the WHO European Region in order to monitor the progress of the obesity epidemic and to make intercountry comparisons within the Region[5]. The system includes weight and height measurements of primary-school children aged 6–9 years whereby each participating country ensures that data are collected according to the common COSI protocol[6,7]. To enable countries to adhere to the protocol according to country-specific legal and ethical requirements (e.g. those that prohibit the collection of entire birth dates of children or those that require active written parental consent) or to adapt to other local circumstances (e.g. schools that do not provide education in the morning), some intercountry variation in data collection procedures has been permitted. Identifying intercountry variations in data collection procedures is essential in order to assess the validity and precision of cross-country comparisons, and may lead to changes in future monitoring practices.

The COSI protocol allows flexibility in terms of (1) methodological factors associated with the examiner (e.g. the selection of the examiners or the duration of training that was provided to them); (2) methodological factors associated with the child (e.g. age determination of the child based on complete dates of birth and complete dates of measurement or only on month and year of birth or month and year of the measurement timing); and (3) other data collection practices (e.g. choice of anthropometric measurement equipment, timing and duration of data collection during the school year, the time of day when measurements were taken, and types of clothing worn by children during their weight and height measurements)[5].

This paper focuses on the third group of data collection practices for which intercountry differences were observed during the COSI rounds that took place in school years 2007/2008 and 2009/2010. In particular, two practices will be addressed for which data were available for all measured children, namely (1) the type of clothing worn by children during their weight

and height measurements and the weight adjustments applied by the participating countries for the clothes worn; and (2) the timing of the survey within a COSI data collection round and the duration of the anthropometric measurements. The purpose of this paper is to determine the impact of the observed intercountry differences of these two practices on the estimates of countries' mean age-adjusted Z-score values of children's weight or body mass index (BMI), as well as on the countries' prevalence estimates of overweight or obesity. If the results suggest a possible impact that could not be corrected in the data analyses, we would need to revise the protocol in order to minimize intercountry variations in future COSI rounds.

METHODS

WHO European Childhood Obesity Surveillance Initiative

At the first consultation with Member States in 2005[8] in the process leading to the WHO European Ministerial Conference on Counteracting Obesity in 2006[9], Member States recognized the need for harmonized surveillance systems among primary-school children, which would include measured weight and height data on which policy development within the Region could be based. The WHO Regional Office for Europe and some Member States established COSI in response to this need[5]. The first COSI data collection round took place in school year 2007/2008, with 13 countries participating: Belgium (Flanders), Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden. The second round was conducted in school year 2009/2010, with four new countries joining –Greece, Hungary, Spain and the former Yugoslav Republic of Macedonia– and two initial countries deciding not to participate in the second round (Bulgaria and Sweden)[5]. All countries' datasets, except from Cyprus in Rounds 1 and 2 and Malta in Round 2, were delivered in line with the COSI protocol[6,7] and are used for this paper.

COSI targets 6-, 7-, 8- and 9-year-old children whereby countries can choose one or more of these four age groups. The entire population of interest was included by Belgium (Flanders) and Malta (all second grade primary-school classes). Nationally representative samples of children were drawn in all other countries in which most of them applied a two-stage cluster sampling using the primary school as the primary sampling unit and school classes as the secondary sampling unit. Further details about the sampling procedures in each country have been described elsewhere[5,10,11]. Because data from Madeira were collected one year after the other Portuguese regions in both rounds, these data were excluded from the Portuguese dataset. In addition, the data collected in the Czech Republic from October–December 2009 and from January–April 2011 in Round 2 were not taken into account. This way, the time span in Round 2 for the Czech Republic was kept the same as the time span in Round 1 (January–December) and did not go beyond one year.

The COSI protocol[6,7] is in accordance with the *international ethical guidelines for biomedical research involving human subjects*[12]. Depending on country policies, the procedures were approved by local ethical committees. Parents were fully informed about all study procedures, and their informed consent was obtained. Children's consent was obtained prior to the anthropometric measurements, and confidentiality of all collected and archived data was ensured[5].

Adjusting for the weight of clothes

The COSI protocol for both data collection rounds indicates that during anthropometry children should wear normal, light indoor clothing without shoes or socks[6,7]. If this was not the case, the children were asked to take off all heavy clothing (coats, sweaters, jackets, etc.), their shoes and socks. They were also asked to remove wallets, mobile phones, key chains, belts or any other objects, including hair ornaments, and braids were undone. The clothes worn by a child during the weight and height measurements were indicated on the examiner's record form by using four pre-defined types of clothing: 'underwear only', 'gym clothes (e.g. shorts and t-shirt only)', 'light clothing (e.g. t-shirt, cotton trouser or skirt)', or 'heavy clothing (e.g. sweater and jeans)'. When an examiner found it difficult to choose one of these four answer options, the examiner had to specify the clothes in detail, had to select the answer option 'other', and had to make an estimate of the weight of these clothes afterwards.

In the data elaboration, we adjusted the measured body weight values for the weight of the clothes worn by the children during anthropometry. For the countries that preferred to use their own clothes adjustment weights for the four pre-defined types of clothing, these country-specific adjustment weights were used. The country-specific adjustment weights were obtained by measuring a sample of clothes for each type of clothing or taken from other country surveys. For those countries that did not have their own clothes adjustment weights, we used for each of the four pre-defined types of clothing the average of the clothes adjustment weights provided by Bulgaria, Latvia, Lithuania, Malta, Norway, Portugal and Sweden in Round 1, hereafter called 'average non-country-specific adjustment weights'.

Timing of the survey

The COSI protocol for both rounds indicates that data should be collected once in a given school year[6,7]. Having the data collection taken place during the same time period of the year was not mandatory. Thus countries could decide the seasonal period when measurements could take place. It was, however, specified that data collection should be avoided during the first two weeks of a new school term or immediately after a major holiday. Countries were also requested to carry out the measurements in all sampled children over the shortest possible period, preferably within four weeks and no longer than eight (Round 1 protocol[6]) or 10 weeks (Round 2 protocol[7]).

The date that weight and height measurements were taken was recorded for each child. This was mandatory for all countries in both rounds. For each country and for each round separately, we calculated the duration of data collection in days by subtracting the first measurement date from the last measurement date that appeared in a country-specific dataset.

Anthropometry

Children's weight and height were measured by fieldworkers who were trained in measuring according to WHO standardized techniques[3,6,7]. Body weight was measured in kilograms with portable digital scales (mainly manufacturer-calibrated) and recorded to the nearest 100 grams (0.1 kg). Body height was measured in centimetres, standing upright, with portable stadiometers and the reading was taken to the last completed 1 millimetre (0.1 cm). BMI was calculated using the formula: weight (kg) divided by height squared (m^2).

For each entire country-specific dataset by round, we computed, as outcome measures for the analyses, mean weight-for-age (W/A) and BMI-for-age (BMI/A) Z-scores and we estimated prevalence figures of overweight (BMI/A > +1 Z-score) and obesity (BMI/A > +2 Z-scores) using the 2007 WHO growth reference[13]. According to WHO criteria, the prevalence estimates for overweight children include those who are obese[3]. To evaluate the influence of the weight adjustments made for the clothes worn on these outcome measures, a first set of computed outcome measures was based on the unadjusted child's body weight measurement, and the second set on the body weight measure that was adjusted for the clothes worn using the average non-country-specific adjustment weights for the four pre-defined types of clothing. In addition, we computed a third set of outcome measures for the countries that provided their own country-specific clothes adjustment weights, whereby the body weight measure was adjusted for the clothes worn using these adjustment weights. We also calculated relative difference percentages between the unadjusted and clothes-adjusted Z-score values and prevalence figures.

In addition, in order to evaluate monthly fluctuations in mean BMI/A Z-score values, we split the entire data collection period of a country-specific dataset in each round in calendar months. By country and targeted age group, for each month that included at least 5% of the total group of measured children, we calculated the mean BMI/A Z-score value, whereby we used the clothes adjustment weights as applied by the countries. Children with a biologically implausible BMI/A Z-score value below –5 or above +5 relative to the WHO growth reference median[13] were excluded from these calculations.

Statistical analyses

All statistical analyses, except the Games–Howell *post hoc* tests[14], were performed in Stata version 10.1 (StataCorp, College Station, TX, USA) and a P value of < 0.05 was used to define

statistical significance. The Games–Howell *post hoc* tests were performed in SPSS version 20.0 (IBM, Armonk, NY, USA).

Adjusting for the weight of clothes

Descriptive statistics (mean, standard deviation (SD), and interquartile range values for continuous variables and frequencies (%) for categorical variables) were used to summarize the types of clothing worn during the anthropometric measurements and the clothes adjustment weights applied for each country-specific dataset in both rounds. Analytical statistics included Pearson's chi-squared tests for categorical variables.

Timing of the survey

For each country that measured children over a continuous period of 3 months or more in each round, whereby each month included at least 5% of the total group of measured children, a two-way analysis of variance (ANOVA) was applied to assess the statistical interaction of monthly period and sex of the child on mean BMI/A Z-score values by each of the four targeted age groups. This was to review whether further analyses would need to be done for boys and girls separately. In the case of a statistically significant interaction, a one-way ANOVA was performed to assess significant differences across monthly periods by sex. In the case of no significant interaction effect, two-way ANOVA without the interaction term (additive model) was performed to assess the main effects of monthly period and sex on the values. Moreover, the Levene's test[15] was used to assess the homogeneity of variances between the monthly periods. In the cases of heterogeneity of variances, of a significant main effect of monthly period in the one-way ANOVA models for boys or girls, or of a significant main effect of monthly period in the two-way ANOVA additive model, the Games–Howell *post hoc* test[14] was applied for the multiple comparisons of mean BMI/A Z-score values between monthly periods. Eligible country-specific datasets for these comparative analyses of anthropometric outcome measures across at least three calendar months came from Belgium, the Czech Republic and Sweden in Round 1, and from Belgium, the Czech Republic, Greece, Lithuania, and Spain in Round 2.

RESULTS

Adjusting for the weight of clothes

A total of 168 864 children (85 906 boys and 82 858 girls) from 12 countries were included in the data analyses for Round 1 and a total of 224 920 children (114 457 boys and 110 463 girls) from 13 countries for Round 2. Table **6.1** displays for both rounds the proportion of children that wore underwear only, gym clothes, light clothing or heavy clothing when their weight and height were measured. The proportion of children wearing any of the first

Table 6.1 Proportion (%) of children aged 6–9 years wearing different types of clothing during their weight and height measurements, by COSI round and country

Round and country	Targeted age group (*years*)	Sample size* (*n*)	Clothes worn when weight and height were measured (%)				
			Underwear only	Gym clothes	Light clothing	Heavy clothing	Other†
Round 1							
Belgium	6, 7, 8, 9	126 078	ND	100	ND	ND	ND
Bulgaria	7	2511	17.68	26.96	50.34	5.02	0
Czech Republic	7	915	99.23	0.11	0.66	0	0
Ireland	7	2383	0	3.73	93.24	3.02	0
Italy	8, 9	7997	0.13	0.54	38.50	60.84	0
Latvia	7	3251	20.79	10.77	49.65	18.79	0
Lithuania	7	3309	6.44	18.98	53.37	21.21	0
Malta	6	2115	ND	ND	100	ND	ND
Norway	8	2834	0	ND	53.92	37.93	8.15
Portugal	7	1815	84.24	7.11	6.83	1.27	0.55
Slovenia	6, 7, 8	11 940	ND	100	ND	ND	ND
Sweden	7, 8	3716	5.54	83.88	7.75	1.53	1.29
Round 2							
Belgium	6, 7, 8, 9	133 156	ND	100	ND	ND	ND
Czech Republic	7	1271	97.72	0.24	1.81	0.24	0
Greece	7, 9	5269	0.15	75.59	18.03	6.23	0
Hungary	7	1235	34.74	14.01	44.45	6.80	0
Ireland	7, 9	1986	0	1.41	93.81	4.78	0
Italy	8, 9	41 672	0.15	1.08	39.96	58.81	0
Latvia	7	2838	21.39	15.61	52.64	8.14	2.22
Lithuania	7, 9	6721	35.35	10.73	50.96	2.96	0
Norway	8	2621	0	ND	64.82	30.60	4.58
Portugal	7	1813	68.95	3.81	22.12	3.25	1.88
Slovenia	6, 7, 8, 9	15 938	ND	100	ND	ND	ND
Spain	6, 7, 8, 9	7656	ND	ND	100	ND	ND
The former Yugoslav Republic of Macedonia	7	2744	ND	ND	100	ND	ND

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; ND, not determined because the country did not use this type of clothing in the questionnaire to describe the clothes worn by the child when anthropometric measures were taken.

* Only children whose age fell within the country-specific targeted age group(s) were included; † This answer option was selected when an examiner found it difficult to choose one of the other four pre-defined answer options for the clothes worn by a child.

three mentioned types of clothing covered the entire range from 0% to 100% between countries, whereas the range for 'heavy clothing' was slightly narrower (0–60.8%). Apart from some measurements in Latvia, Norway, Portugal and Sweden (see Table 6.1), examiners generally did not find it difficult to choose one of the four pre-defined answer options for the clothes worn by a child. In both rounds, the distribution of the number of anthropometric measurements over the four pre-defined types of clothing was different for the various countries (Pearson's chi-squared test $P < 0.001$).

Table 6.2 presents the adjustment weights as applied by the countries for each type of clothing. Ten countries used their own clothes adjustment weights for the pre-defined types of clothing. The other countries used the average non-country-specific clothes adjustment weights for the four categories: 'underwear only' – 0 grams, 'gym clothes' – 130 grams, 'light clothing' – 195 grams and 'heavy clothing' – 600 grams. Table 6.2 also presents the overall mean clothes adjustment, as obtained by multiplying the clothes adjustment weights used for each type of clothing with the proportion in which each type of clothing occurred. For those 10 countries with their own adjustment weights, an overall mean country-specific clothes adjustment could be calculated, resulting in an average weight adjustment of 244 grams in Round 1 and of 302 grams in Round 2. It should be noted that some of these countries did not use all pre-defined types of clothing (see Table 6.2). For all countries, an overall mean clothes adjustment was calculated using the average non-country-specific adjustment weights. The use of these average clothes adjustments resulted in an average body weight adjustment of 190 grams in Round 1 and of 179 grams in Round 2. For those 10 countries with their own adjustment weights, the overall mean country-specific clothes adjustment was higher than the overall mean non-country-specific clothes adjustment, 18 grams in Round 1 and 93 grams in Round 2 (Table 6.2).

Table 6.3 shows the unadjusted and clothes-adjusted mean W/A Z-score values and mean BMI/A Z-score values for each country by round. Reviewing the 10 countries in Table 6.3 that used their own country-specific clothes adjustments, the unadjusted and country-specific clothes-adjusted mean W/A Z-score and BMI/A Z-score values were the same for Portugal and Sweden in Round 1. The unadjusted mean W/A Z-score values were reduced by 10–13% in Round 1 and by 3–17% in Round 2 when body weight was adjusted for the clothes worn. The country-specific clothes-adjusted mean BMI/A Z-score values were 13–33% lower in Round 1 and 6–25% lower in Round 2 than the unadjusted values. In absolute terms, the country-specific clothes-adjusted mean BMI/A Z-score values in Bulgaria, Italy, Latvia, Lithuania, Malta, Norway, Portugal and Slovenia were about 0.04–0.14 Z-score lower than the unadjusted values, and in the former Yugoslav Republic of Macedonia 0.19 Z-score lower. Furthermore, Table 6.3 highlights that the use of the average non-country-specific clothes adjustments led to smaller reductions of the unadjusted values than the use of country-specific clothes adjustments in all countries except Norway (both rounds), Portugal (Round 1) and Sweden

Table 6.2 Adjustment weights (grams) for different types of clothing as applied by the countries and weighted mean clothes adjustment (grams) for the entire country dataset, by COSI round and country

Round and country	Clothes adjustment weights (*grams*)					Weighted mean clothes adjustment (*grams*)*		
	Underwear only	Gym clothes	Light clothing	Heavy clothing	Other[†]	Country-specific[‡]	Non-country-specific[§]	Absolute change country-specific – non-country-specific
Round 1								
Belgium[¶]	0	130	195	600	ND	NA	130	NA
Bulgaria	85	220	270	590	ND	240	163	– 77
Czech Republic[¶]	0	130	195	600	ND	NA	1	NA
Ireland[¶]	0	130	195	600	ND	NA	205	NA
Italy	0–92[#]	137–250[#]	260–450[#]	455–734[#]	ND	478	441	– 37
Latvia	0	165	300	800	ND	317	224	– 93
Lithuania	0	265	380	625	ND	386	256	– 130
Malta	ND	ND	230	ND	ND	230	195	– 35
Norway	0	ND	100	500	0–500[#]	275	364	+ 89
Portugal	0	0	0	600	0	8	30	+ 22
Slovenia[¶]	0	130	195	600	ND	NA	130	NA
Sweden	0	0	100	500	0–500[#]	17	135	+ 118
Interquartile range	0[‖]	220[‖]	200[‖]	125[‖]	ND	228	110	141[‡]
Mean (SD)	14 (35)[‖]	130 (124)[‖]	197 (134)[‖]	603 (110)[‖]	ND	244 (164)	190 (125)	– 18 (88)[‖]
Round 2								
Belgium[¶]	0	130	195	600	ND	NA	130	NA
Czech Republic[¶]	0	130	195	600	ND	NA	5	NA
Greece[¶]	0	130	195	600	ND	NA	171	NA
Hungary[¶]	0	130	195	600	ND	NA	146	NA
Ireland[¶]	0	130	195	600	ND	NA	213	NA
Italy	28–92[#]	108–250[#]	252–449[#]	455–826[#]	ND	470	432	– 38
Latvia	0	165	300	800	130–800[#]	254	177	– 77

Lithuania	0	265	380	625	ND	241	131	– 110
Norway	0	ND	100	500	0–500[#]	236	328	+ 92
Portugal	0	100	400	600	0–400[#]	112	68	– 44
Slovenia	ND	300	ND	ND	ND	300	130	– 170
Spain[¶]	0	130	195	600	ND	NA	195	NA
The former Yugoslav Republic of Macedonia	ND	ND	500	ND	ND	500	195	– 305
Interquartile range	0[‖]	150[‖]	100[‖]	163[‖]	ND	234	65	132[ⁱ]
Mean (SD)	0 (0)[‖]	208 (92)[‖]	336 (150)[‖]	631 (125)[‖]	ND	302 (138)	179 (108)	– 93 (123)[ǁ]

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; NA, not applicable because the country did not use its own clothes adjustment weights; ND, not determined, because none of the children were classified into this category; SD, standard deviation.

* The weighted mean of the clothes adjustment weights for the entire country dataset was calculated by firstly multiplying the clothes adjustment weight used for each type of clothing by a country and the proportion that each type of clothing occurred in a dataset and secondly by adding up the weighted mean for each type of clothing; [†] This answer option was selected when an examiner found it difficult to choose one of the four other pre-defined answer options for the clothes worn by a child; [‡] The country-specific clothes adjustment weights that were provided for all pre-defined types of clothing were applied to calculate the weighted mean of the clothes adjustment weights for the entire country dataset; [§] The average non-country-specific clothes adjustment weights were applied for the four pre-defined answer options ('underwear only' – 0 grams, 'gym clothes' – 130 grams, 'light clothing' – 195 grams and 'heavy clothing' – 600 grams) and country-specific clothes adjustment weights for the option 'other' (if applicable) to calculate the weighted mean of the clothes adjustment weights for the entire country dataset; [¶] This country did not provide its own country-specific clothes adjustment weights; thus, the average non-country-specific adjustment weights were applied, based on the single country-specific adjustment weights provided by Bulgaria, Latvia, Lithuania, Malta, Norway, Portugal and Sweden for each pre-defined type of clothing in Round 1; [#] Various adjustment weights, based on a description of the clothes worn, were used; hence, a range is indicated; [‖] All single country-specific clothes adjustment weights for a type of clothing (except those from Italy) were included in the calculation of these values; [ⁱ] The interquartile range of the absolute change values of the countries is given; [ǁ] The mean (SD) of the absolute change values of the countries is given.

Table 6.3 Unadjusted and clothes-adjusted mean values of weight-for-age Z-score and BMI-for-age Z-score of children aged 6–9 years* and relative difference between the unadjusted and clothes-adjusted values, by COSI round and country

Round and country	Mean W/A Z-score			Relative difference unadjusted – clothes-adjusted mean W/A Z-score (%)		Mean BMI/A Z-score			Relative difference unadjusted – clothes-adjusted mean BMI/A Z-score (%)	
	Unadjusted	Clothes-adjusted Country-specific†	Clothes-adjusted Non-country-specific‡	Country-specific†	Non-country-specific‡	Unadjusted	Clothes-adjusted Country-specific†	Clothes-adjusted Non-country-specific‡	Country-specific†	Non-country-specific‡
Round 1										
Belgium	0.43	NA	0.40	NA	– 7.0	0.28	NA	0.24	NA	– 14.3
Bulgaria	0.47	0.41	0.43	– 12.8	– 8.5	0.44	0.35	0.38	– 20.5	– 13.6
Czech Republic	0.51	NA	0.51	NA	0	0.17	NA	0.17	NA	0
Ireland	0.61	NA	0.56	NA	– 8.2	0.62	NA	0.55	NA	– 11.3
Italy	0.92	0.82	0.83	– 10.9	– 9.8	1.01	0.88	0.89	– 12.9	– 11.9
Latvia	0.62	0.54	0.56	– 12.9	– 9.7	0.38	0.26	0.30	– 31.6	– 21.1
Lithuania	0.72	0.63	0.66	– 12.5	– 8.3	0.42	0.28	0.33	– 33.3	– 21.4
Malta	0.55	0.48	0.49	– 12.7	– 10.9	0.74	0.64	0.66	– 13.5	– 10.8
Norway	0.60	0.54	0.52	– 10.0	– 13.3	0.37	0.29	0.26	– 21.6	– 29.7
Portugal	0.68	0.68	0.67	0	– 1.5	0.72	0.72	0.71	0	– 1.4
Slovenia	0.82	NA	0.79	NA	– 3.7	0.49	NA	0.45	NA	– 8.2
Sweden	0.59	0.59	0.56	0	– 5.1	0.31	0.31	0.27	0	– 12.9
Round 2										
Belgium	0.43	NA	0.39	NA	– 9.3	0.27	NA	0.22	NA	– 18.5
Czech Republic	0.58	NA	0.57	NA	– 1.7	0.28	NA	0.28	NA	0
Greece	1.18	NA	1.15	NA	– 2.5	1.09	NA	1.05	NA	– 3.7

Hungary	0.61	NA	0.57	NA	– 6.6	0.39	NA	0.33	NA	– 15.4
Ireland	0.56	NA	0.51	NA	– 8.9	0.55	NA	0.49	NA	– 10.9
Italy	0.85	0.76	0.76	– 10.6	– 10.6	0.90	0.77	0.78	– 14.4	– 13.3
Latvia	0.60	0.54	0.56	– 10.0	– 6.7	0.36	0.27	0.30	– 25.0	– 16.7
Lithuania	0.63	0.58	0.60	– 7.9	– 4.8	0.31	0.24	0.27	– 22.6	– 12.9
Norway	0.68	0.63	0.61	– 7.4	– 10.3	0.48	0.41	0.38	– 14.6	– 20.8
Portugal	0.68	0.66	0.67	– 2.9	– 1.5	0.66	0.62	0.63	– 6.1	– 4.5
Slovenia	0.82	0.75	0.79	– 8.5	– 3.7	0.50	0.40	0.46	– 20.0	– 8.0
Spain	0.89	NA	0.85	NA	– 4.5	0.89	NA	0.83	NA	– 6.7
The former Yugoslav Republic of Macedonia	0.77	0.64	0.72	– 16.9	– 6.5	0.77	0.58	0.69	– 24.7	– 10.4

Abbreviations: BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; NA, not applicable because the country did not use its own clothes adjustment weights; W/A, weight-for-age.

* Only children whose age fell within the country-specific targeted age group(s) were included (see Table **6.1**); † Body weight was adjusted for the clothes worn when measured using country-specific adjustment weights for all four pre-defined types of clothing and the clothing answer option 'other'; ‡ Body weight was adjusted for the clothes worn when measured using the average non-country-specific adjustment weights for the four pre-defined types of clothing 'underwear only', 'gym clothes', 'light clothing' and 'heavy clothing', and country-specific adjustment weights for the clothing answer option 'other'.

(Round 1). In general, the country-specific clothes-adjusted W/A Z-score values were 1.1–10.4% higher than the non-country-specific clothes-adjusted values, relative to the unadjusted values; the country-specific clothes-adjusted BMI/A Z-score values were 1.0–14.3% higher than the non-country-specific clothes-adjusted values, relative to the unadjusted values.

Table 6.4 gives the unadjusted and clothes-adjusted overweight and obesity prevalence estimates for each country by round. Irrespective of the kind of clothes adjustment weights used (country-specific or average non-country-specific ones), Table 6.4 indicates that the clothes-adjusted overweight prevalence estimates were relatively lower than the unadjusted estimates by as much as 12%, and the clothes-adjusted obesity prevalence estimates were relatively lower than the unadjusted estimates by as much as 10%. Referring to the 10 countries with their own clothes adjustment weights, Table 6.4 also suggests that the use of the average non-country-specific clothes adjustments led to smaller reductions of the unadjusted overweight and obesity prevalence estimates than the use of country-specific clothes adjustments in all countries, except in Norway (both rounds), Portugal (Round 1) and Sweden (Round 1) where the opposite was observed. In general, the clothes-adjusted country-specific overweight estimates were 0.4–6.9% higher than the clothes-adjusted non-country-specific overweight estimates, relative to the unadjusted estimates; the clothes-adjusted country-specific obesity estimates were 0.7–4.8% higher than the clothes-adjusted non-country-specific obesity estimates, relative to the unadjusted estimates.

Timing of the survey

Figure 6.1 portrays that in Round 1 the majority of the countries started the anthropometric data collection in the first semester of 2008. Figure 6.2 illustrates that in Round 2, seven countries started the anthropometric data collection in the first semester of 2010 and five countries in the second semester of 2010. Furthermore, five out of 12 countries in Round 1 took the anthropometric measures within the indicated period of maximum eight weeks (or 56 days) (Figure 6.1) and nearly five out of 13 countries in Round 2 measured the children within ten weeks (or 70 days) (Figure 6.2). Belgium and the Czech Republic took measures over almost an entire year period in both rounds.

Figure 6.3 shows the mean BMI/A Z-score values (combined sexes) by monthly period for each of the targeted age groups in the three eligible countries in Round 1, and Figure 6.4 shows the mean BMI/A Z-score values by monthly period for each of the targeted age groups in the five eligible countries in Round 2. No statistically significant differences in mean BMI/A Z-score values between monthly periods were observed in the Czech Republic, Lithuania and Sweden, whereas significant monthly fluctuations were observed in 6- and 9-year-olds in Belgium in Round 1 (Figure 6.3) as well as in some of the targeted age groups in Belgium, Greece and Spain in Round 2 (Figure 6.4).

Table 6.5 gives the results of the multiple comparisons that were performed for these three countries with statistically significant monthly fluctuations. A few monthly periods were different from the other ones. For instance, the mean BMI/A Z-score values among Belgian 9-year-olds in Round 1 did not differ from October 2007 to April 2008 (range 0.27–0.34) whereas the mean value of 0.16 for September 2007 was statistically significantly different. The mean values among Spanish 8-year-olds in Round 2 did not statistically significantly differ between December 2010 and March 2011 (range: 0.73–0.90) and between January and April 2011 (range: 0.87–1.04).

DISCUSSION

We have addressed in this paper two data collection practices for which the COSI protocol in Rounds 1 and 2 allowed some flexibility. The aim was to assess the impact of this flexibility on weight or BMI outcome measures.

Adjusting for the weight of clothes

The first practice refers to the clothes worn by the children during measurement and the weights used to adjust for the children's measured body weight. According to the COSI protocol, children should wear light indoor clothing during the weight and height measurements. Although this was followed by 95% or more of the children in almost all countries, Latvia and Lithuania in Round 1 and Italy and Norway in both rounds did not adhere to the standardization of this practice. In these four countries, 19–61% of the children wore heavy clothing (Table 6.1), probably due to low temperature in the measurement rooms. For example, because heating did not work appropriately in some schools in Latvia, the children could not be asked to take off their heavy clothing. On the other hand, adherence to this aspect of the protocol is not that important, since we may adjust for the heavy clothing worn in the data elaboration of the measured body weight.

Although the examiners had four pre-defined options for the classification of the children's clothing, it is not surprising that most classifications of the children's clothing arrived in the first three options. This is most likely due to the protocol's description ‘wearing light indoor clothing’. In fact, some countries (Belgium, Malta, Slovenia, Spain, and the former Yugoslav Republic of Macedonia) used one answer option for all children (e.g. ‘gym clothes’ or ‘light clothing’), probably because it was organised that way. In Slovenia, for example, COSI is integrated into a procedure that assesses during physical education classes the growth and motor development (including measurements of weight and height) of children that fall within the COSI age range, which thus meant that all children wore gym clothes and not any other type of clothing[5].

Table 6.4 Unadjusted and clothes-adjusted prevalence of overweight (including obesity) and prevalence of obesity in children aged 6–9 years* and relative difference between the unadjusted and clothes-adjusted values, by COSI round and country

Round and country	Prevalence of overweight† (%)			Relative difference unadjusted – clothes-adjusted prevalence of overweight (%)		Prevalence of obesity† (%)			Relative difference unadjusted – clothes-adjusted prevalence of obesity (%)	
	Unadjusted	Clothes-adjusted Country-specific‡	Clothes-adjusted Non-country-specific§	Country-specific‡	Non-country-specific§	Unadjusted	Clothes-adjusted Country-specific‡	Clothes-adjusted Non-country-specific§	Country-specific‡	Non-country-specific§
Round 1										
Belgium	22.8	NA	21.9	NA	– 3.9	7.4	NA	7.2	NA	– 2.7
Bulgaria	29.4	28.3	28.8	– 3.7	– 2.0	13.1	12.6	12.7	– 3.8	– 3.1
Czech Republic	21.0	NA	21.0	NA	0	7.9	NA	7.9	NA	0
Ireland	31.4	NA	29.5	NA	– 6.1	9.8	NA	9.3	NA	– 5.1
Italy	48.4	45.2	45.4	– 6.6	– 6.2	23.1	21.8	21.8	– 5.6	– 5.6
Latvia	24.3	21.6	22.4	– 11.1	– 7.8	7.4	6.7	7.0	– 9.5	– 5.4
Lithuania	25.8	23.0	24.1	– 10.9	– 6.6	9.3	8.4	8.6	– 9.7	– 7.5
Malta	35.1	32.4	32.7	– 7.7	– 6.8	14.5	13.9	13.9	– 4.1	– 4.1
Norway	25.2	23.0	22.3	– 8.7	– 11.5	7.2	6.7	6.5	– 6.9	– 9.7
Portugal	38.1	38.1	38.0	0	– 0.3	14.8	14.8	14.7	0	– 0.7
Slovenia	31.3	NA	30.3	NA	– 3.2	12.7	NA	12.4	NA	– 2.4
Sweden	24.2	24.1	23.3	– 0.4	– 3.7	7.4	7.3	7.2	– 1.4	– 2.7
Round 2										
Belgium	22.4	NA	21.5	NA	– 4.0	7.5	NA	7.3	NA	– 2.7
Czech Republic	24.2	NA	24.2	NA	0	9.1	NA	9.1	NA	0
Greece	51.2	NA	50.4	NA	– 1.6	24.4	NA	23.6	NA	– 3.3

Hungary	28.0	NA	27.0	NA	– 3.6	12.6	NA	12.3	NA	– 2.4
Ireland	31.3	NA	29.5	NA	– 5.8	8.7	NA	8.2	NA	– 5.7
Italy	45.0	42.0	42.2	– 6.7	– 6.2	20.5	18.9	19.0	– 7.8	– 7.3
Latvia	24.8	23.4	23.8	– 5.6	– 4.0	9.7	9.2	9.3	– 5.2	– 4.1
Lithuania	24.8	23.5	24.0	– 5.2	– 3.2	9.1	8.5	8.8	– 6.6	– 3.3
Norway	29.5	27.7	27.0	– 6.1	– 8.5	9.4	9.0	8.7	– 4.3	– 7.4
Portugal	35.1	34.1	34.5	– 2.8	– 1.7	13.8	13.5	13.6	– 2.2	– 1.4
Slovenia	31.5	29.5	30.5	– 6.3	– 3.2	13.3	12.5	12.9	– 6.0	– 3.0
Spain	43.7	NA	41.9	NA	– 4.1	17.8	NA	17.1	NA	– 3.9
The former Yugoslav Republic of Macedonia	35.0	31.2	33.6	– 10.9	– 4.0	16.9	15.7	16.3	– 7.1	– 3.6

Abbreviations: BMI/A, body mass index-for-age; COSI, Childhood Obesity Surveillance Initiative; NA, not applicable because the country did not use its own clothes adjustment weights; WHO, World Health Organization.

* Only children whose age fell within the country-specific targeted age group(s) were included (see Table 6.1); † Prevalence estimates were based on the 2007 WHO recommended growth reference for school-age children and adolescents[13]. Overweight and obesity were defined as the proportion of children with a BMI/A value above +1 Z-score and above +2 Z-scores, respectively; ‡ Body weight was adjusted for the clothes worn when measured using country-specific adjustment weights for all four pre-defined types of clothing and the clothing answer option 'other'; § Body weight was adjusted for the clothes worn when measured using the average non-country-specific adjustment weights for the four pre-defined types of clothing 'underwear only', 'gym clothes', 'light clothing' and 'heavy clothing', and country-specific adjustment weights for the clothing answer option 'other'.

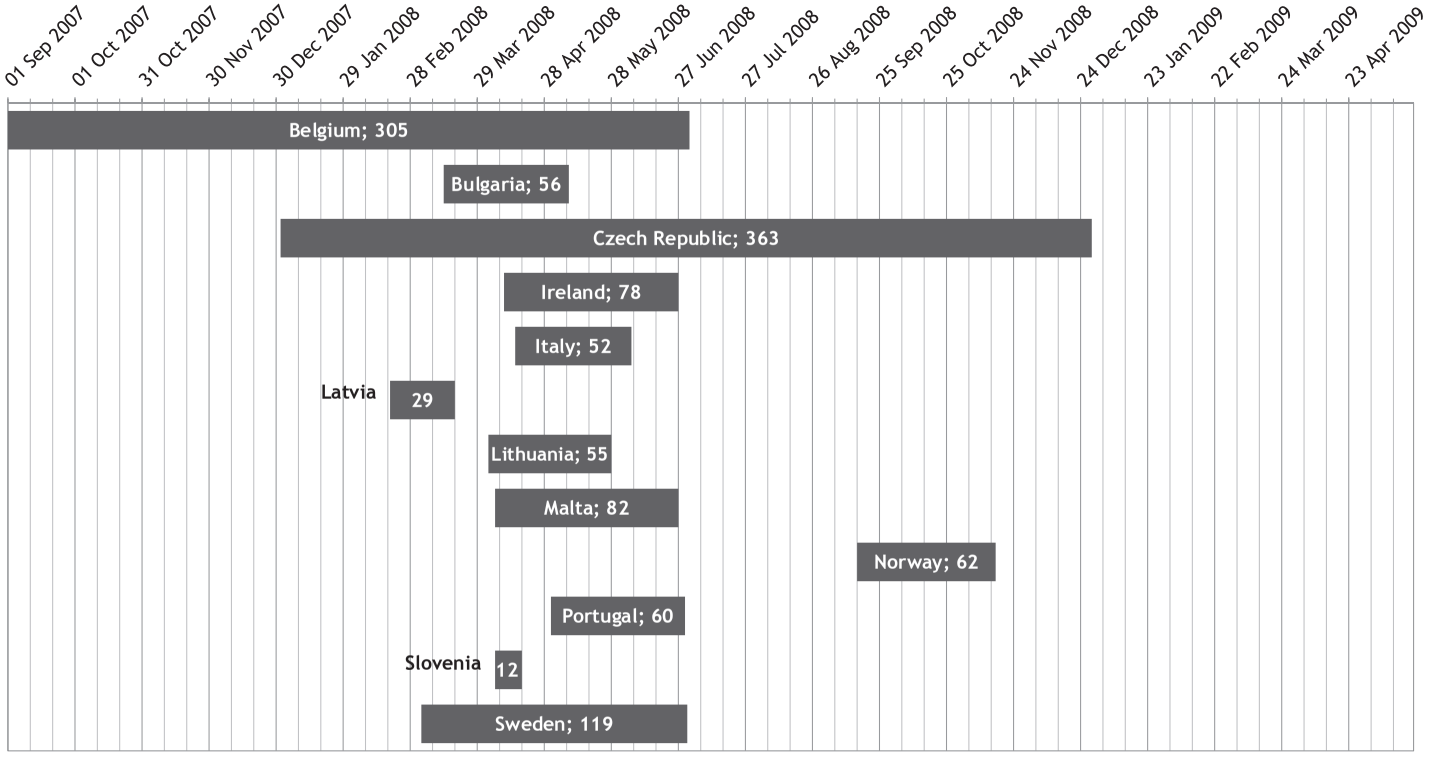


Figure 6.1 Time span of data collection and number of days over which the anthropometric measurements were taken in children aged 6–9 years* by 12 countries in COSI Round 1

Abbreviation: COSI, Childhood Obesity Surveillance Initiative.
Notes. The interval between the major vertical lines is 30 days and the interval between the minor vertical lines 10 days. The numbers in the bars represent the duration in days of the data collection period, which was calculated by subtracting the first measurement date from the last measurement date in the country-specific dataset.
* Only children whose age fell within the country-specific targeted age group(s) were included (see Table 6.1).

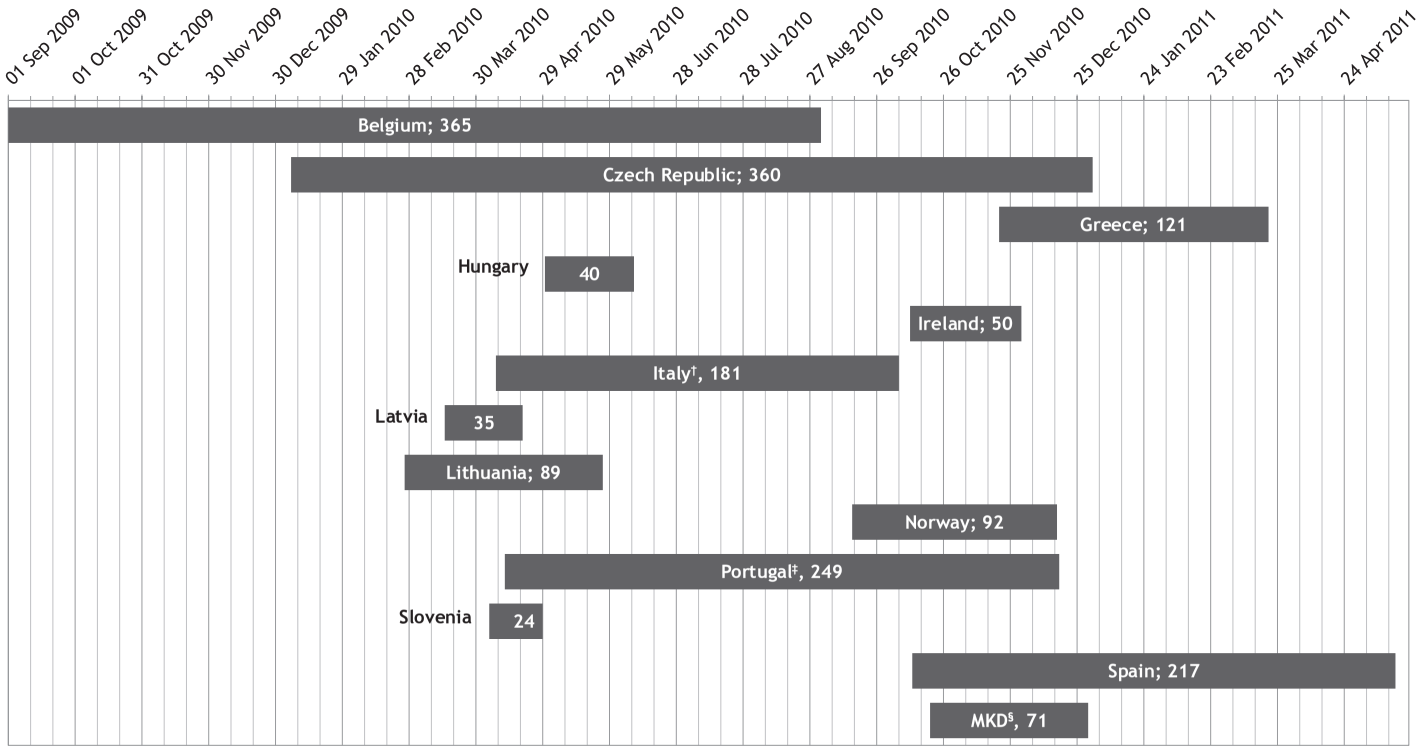


Figure 6.2 Time span of data collection and number of days over which the anthropometric measurements were taken in children aged 6–9 years* by 13 countries in COSI Round 2

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; ISO; International Organization for Standardization; MKD, The former Yugoslav Republic of Macedonia.
Notes. The interval between the major vertical lines is 30 days and the interval between the minor vertical lines 10 days. The numbers in the bars represent the duration in days of the data collection period, which was calculated by subtracting the first measurement date from the last measurement date in the country-specific dataset.
* Only children whose age fell within the country-specific targeted age group(s) were included (see Table 6.1); † The majority of data were collected from April to June 2010. One local health unit in the Veneto region (Italy) collected data from September to October 2010. No data were collected in July and August 2010; ‡ The majority of data were collected in May and June 2010. Few children were measured in April and December 2010. No data were collected from July to November 2010; § MKD is the ISO 3166–1 Alpha-3 country code for the former Yugoslav Republic of Macedonia.

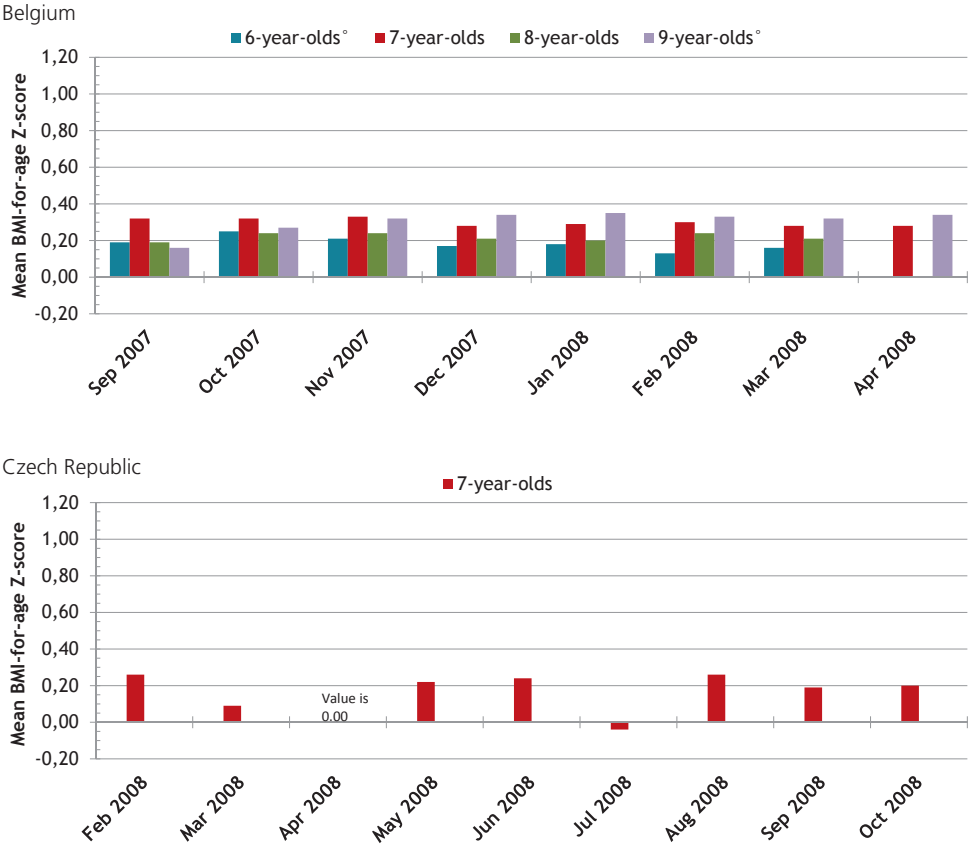


Figure 6.3 Mean BMI-for-age Z-score values* in children aged 6–9 years† by monthly period in three countries in COSI Round 1

Abbreviations: ANOVA, analysis of variance; BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; WHO, World Health Organization.

* Body weight was adjusted for the clothes worn: country-specific clothes adjustment weights by Sweden; average non-country-specific adjustment weights by Belgium and Czech Republic; † Only children whose age fell within the country-specific targeted age group(s) (see Table 6.1) and those with a BMI/A Z-score value between –5 and +5 relative to the WHO growth reference median[13] were included. By targeted age group, monthly BMI/A Z-score values were computed for the months that included at least 5% of the total group of children in a country-specific dataset; ° Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.0001$).

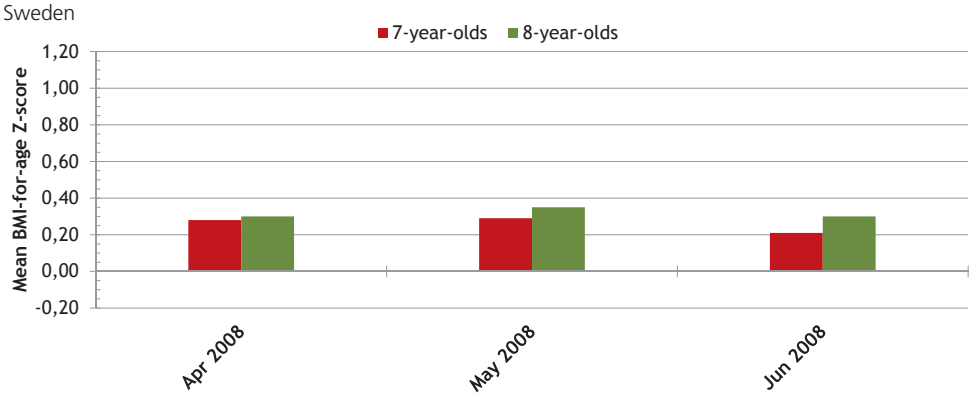
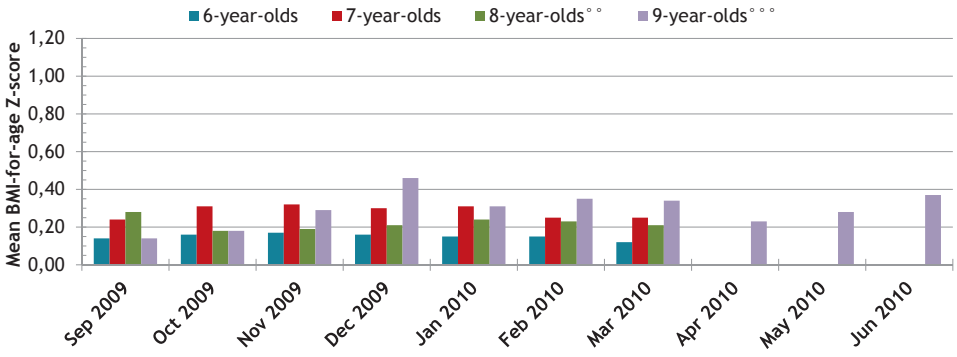


Figure 6.3 (*Contd.*)

The protocol allows countries to use country-specific clothes adjustment weights for each type of clothing. Since these adjustment weights differ significantly between countries, it seems wise to maintain country-specific adjustment weights. On the other hand, some countries did not collect country-specific data and used the average non-country-specific adjustment weights for each category, based on the values of other participating countries. The difference between the country-specific and the average non-country-specific weights was small, which resulted in a difference of 14% or less only between the clothes-adjusted country-specific and the clothes-adjusted non-country-specific outcome measures, relative to the unadjusted values. In future COSI rounds, if more country-specific adjustment weights become available, and thus the average non-country-specific adjustment may be based on more data, then the difference between country-specific and average non-country-specific adjustments weights will probably become even less.

The next question is whether adjusting for the weight of clothes matters. The COSI sample size calculation is based on an 80% power to detect a minimum difference of 0.10 Z-score in mean BMI/A per year at a two-sided 5% significance level[6,7]. In other words, a change in BMI/A Z-score of 0.10 unit per year is considered as important. A difference of around 0.10 Z-score between clothes-adjusted and unadjusted values was observed in some countries. The clothes adjustments applied seem to be important in assessing the countries' absolute mean values of the BMI/A Z-score and the countries' overweight or obesity prevalence estimates and, consequently, in their intercountry comparisons in a data collection round. It would, thus, be advisable to continue adjusting for the clothes worn during the measurements, although the application of clothes weight adjustments may have less impact when studying the change over time of these outcome measures within a country (i.e. inter-round analyses). However, this would only be the case when the type of clothing worn and the country-specific adjustments weights applied will not be different between measurement rounds in a country.

Belgium



Czech Republic

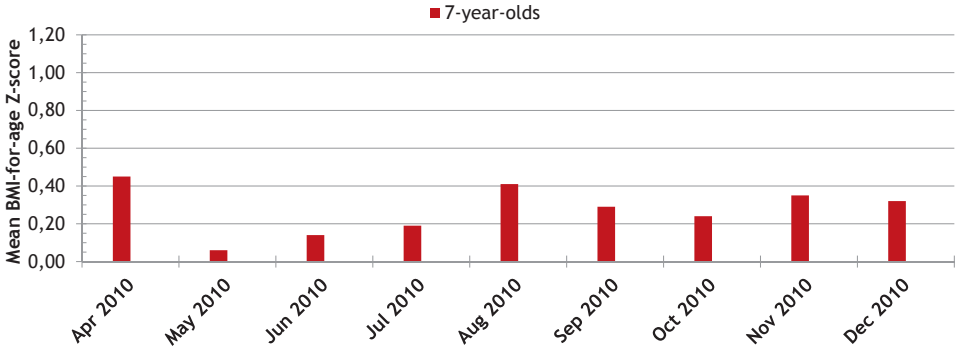
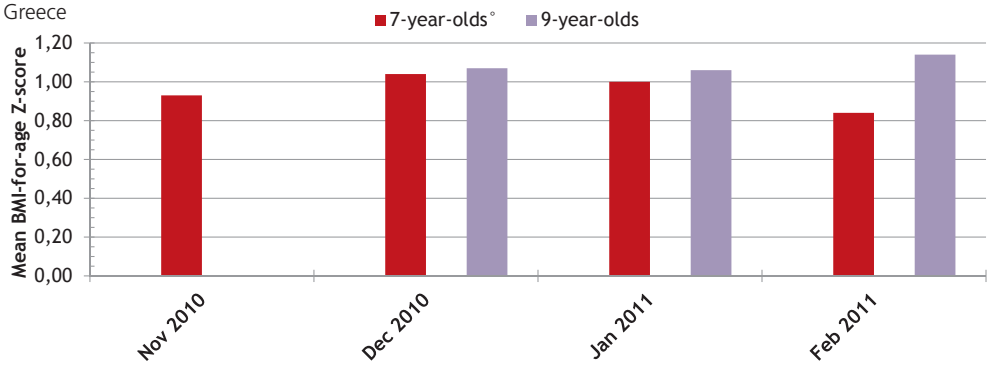


Figure 6.4 Mean BMI-for-age Z-score values in children aged 6–9 years* by monthly period in five countries in COSI Round 2

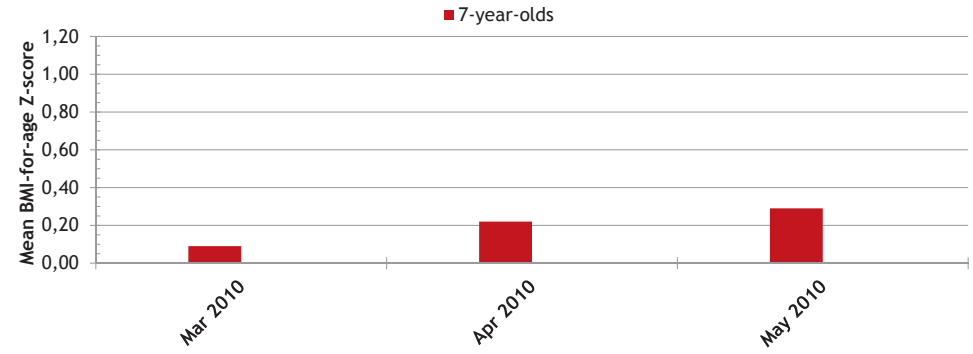
Abbreviations: ANOVA, analysis of variance; BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; WHO, World Health Organization.

* Body weight was adjusted for the clothes worn: country-specific clothes adjustment weights by Lithuania; average non-country-specific adjustment weights by Belgium, Czech Republic, Greece and Spain; † Only children whose age fell within the country-specific targeted age group(s) (see Table 6.1) and those with a BMI/A Z-score value between –5 and +5 relative to the WHO growth reference median[13] were included. By targeted age group, monthly BMI/A Z-score values were computed for the months that included at least 5% of the total group of children in a country-specific dataset; ° Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.05$); °° Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.001$); °°° Statistically significant difference of mean value across monthly periods for the indicated age group (two-way ANOVA without interaction term; $P < 0.0001$).

Greece



Lithuania



Spain

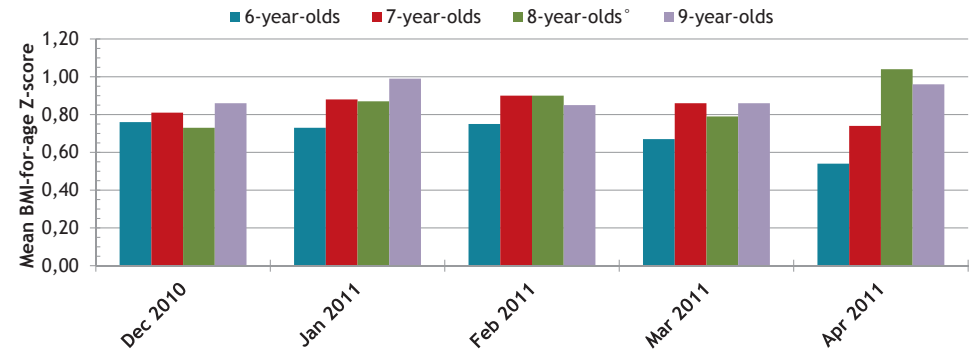


Figure 6.4 (*Contd.*)

Table 6.5 Mean BMI-for-age Z-score values in 6-, 7-, 8- and 9-year-olds in four countries with results of multiple comparisons procedures, by monthly period

Monthly period	Mean BMI/A Z-score			
	6-year-olds	7-year-olds	8-year-olds	9-year-olds
Belgium – Round 1				
Sep 2007	0.19[a,b,c]	ND	ND	0.16[a]
Oct 2007	0.25[b]	ND	ND	0.27[b]
Nov 2007	0.21[a,b]	ND	ND	0.32[b]
Dec 2007	0.17[a,c]	ND	ND	0.34[b]
Jan 2008	0.18[a,c]	ND	ND	0.35[b]
Feb 2008	0.13[c]	ND	ND	0.33[b]
Mar 2008	0.16[a,c]	ND	ND	0.32[b]
Apr 2008	NC	ND	ND	0.34[b]
Belgium – Round 2				
Sep 2009	ND	ND	0.28[a]	0.14[a]
Oct 2009	ND	ND	0.18[b]	0.18[a]
Nov 2009	ND	ND	0.19[b,c]	0.29[b]
Dec 2009	ND	ND	0.21[a,b]	0.46[c]
Jan 2010	ND	ND	0.24[a,c]	0.31[b]
Feb 2010	ND	ND	0.23[a,b]	0.35[b,c]
Mar 2010	ND	ND	0.21[a,b]	0.34[b]
Apr 2010	ND	ND	NC	0.23[a,b]
May 2010	ND	ND	NC	0.28[a,b]
Jun 2010	ND	ND	NC	0.37[b,c]
Greece – Round 2				
Nov 2010	NA	0.93[a,b]	NA	ND
Dec 201	NA	1.04[a]	NA	ND
Jan 2011	NA	1.00[a,b]	NA	ND
Feb 2011	NA	0.84[b]	NA	ND
Spain – Round 2				
Dec 2010	ND	ND	0.73[a]	ND
Jan 2011	ND	ND	0.87[a,b]	ND
Feb 2011	ND	ND	0.90[a,b]	ND
Mar 2011	ND	ND	0.79[a,b]	ND
Apr 2011	ND	ND	1.04[b]	ND

Abbreviations: BMI, body mass index; BMI/A, BMI-for-age; NA, not applicable, because this age group was not one of the country's targeted age group; NC, not calculated, because fewer than 5% of the total group of children for this age group were measured; ND, not determined, because no statistically differences were found in mean value across monthly periods in this targeted age group.

[a,b,c,d] By country and round, within each age group mean values that share the same superscript letter do not statistically significantly differ from each other (Games–Howell *post hoc* test). For example, for the Belgian 9-year-old children in Round 1, the mean value of the children who were measured in September 2007 significantly differ from the other seven monthly periods, whereas the mean values found in the monthly periods October 2007–April 2008 do not significantly differ from each other.

Instead of using clothes adjustment weights for the clothes worn during the anthropometric measurements, the COSI protocol could require that all children should wear underwear only during the measurements. However, this could not be recommended if COSI were to remain a population surveillance system that is acceptable in all participating countries. COSI was designed with the aim to be as simple as possible and not require a major investment of public resources[6,7]. To measure children wearing underwear only will most likely take more time and may accentuate children's sensitivities about their own size, which could increase the potential psychological harm (e.g. anxiety or shame)[16]. Censi *et al*. has performed a validation study with the aim to compare children's body weight measured in underwear with children's weight measured in clothing and then adjusted for the weight of the clothes[17]. Their findings suggest a slight error in the estimation of body weight, which led to a small miscalculation of BMI and a negligible difference in overweight and obesity prevalence estimates.

Timing of the survey

The second practice for which the COSI protocol allowed some flexibility refers to the timing of the survey within a COSI data collection round (i.e. what months or season of the year?) and duration of the anthropometric measurements (i.e. within how many weeks?). According to the COSI protocol, countries could decide on the data collection period within a school year. Indeed, large intercountry variation was found in the timing of data collection (Figures 6.1 and 6.2). Moreover, the countries were asked to measure the children in all sampled classes over the shortest period possible but not longer than 8–10 weeks, with which eight countries could not adhere. However, the monthly fluctuations in clothes-adjusted mean BMI/A Z-score values were only statistically significant in three out of six countries for some targeted age groups (Figures 6.3 and 6.4), whereby 1–3 monthly values only were statistically different within some countries (Table 6.5). The results found in these three countries did not show a systematic seasonal effect (i.e. a particular month/season was different from the others in all countries) and thus do not give us a reason to require countries to measure children in the same seasonal period of the year in next COSI rounds.

Seasonal changes in BMI or weight among schoolchildren are described by several studies that surveyed well-nourished populations and often had as primary aim to report on the effects of school versus non-school period (summer vacation or other school holidays)[4,18–26]. The findings from these studies were inconsistent. Some indicated that the mean BMI/A Z-score values did not change significantly over the school year[20], during the summer season[20] or during a winter break from December to January[22], while one study found a significant increase in BMI/A Z-score values during the summer season[18]. The COSI protocol stresses that data collection should be avoided during the first two weeks of a new school term or immediately after a major holiday, and thus it is unlikely that non-school periods have had an influence on our results.

CONCLUSIONS

The variation found between countries in the timing of the survey and the duration of the anthropometric measurements had no impact or a minor impact on the average children's weight and BMI outcome measures. The intercountry differences observed in the type of clothing worn by children and the clothes weight adjustments used changed the unadjusted outcome measures in almost all countries; thus, taking into account the clothes worn during anthropometry in the analyses remains essential. The difference between the country-specific and the average non-country-specific clothes adjustment weights was small. In conclusion, the findings of the present study suggest that the built-in flexibility in the COSI protocol concerning the data collection practices addressed in the paper can be maintained in upcoming COSI rounds and thus do not necessitate a revision of the protocol.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interests regarding the publication of this paper.

AUTHOR CONTRIBUTIONS

TW conceptualized and drafted the manuscript and conducted all analyses; JvR made substantial contributions to the conception and drafts of the manuscript, as well as interpretation of the results; PvtV was involved in critically reviewing drafts of the manuscript; AS, AY and LL gave substantial input to a draft of the manuscript and contributed with data collection and data cleaning; IS, VFS, NPF, ÉM, MH and MK reviewed a draft of the manuscript and contributed with data collection and data cleaning; AR, RH, GS, VD, IP, AP, LB, MH and JB contributed with data collection and data cleaning. All authors contributed to and approved the final manuscript.

DISCLAIMER

TW and JB are staff members of the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions or the stated policy of the World Health Organization.

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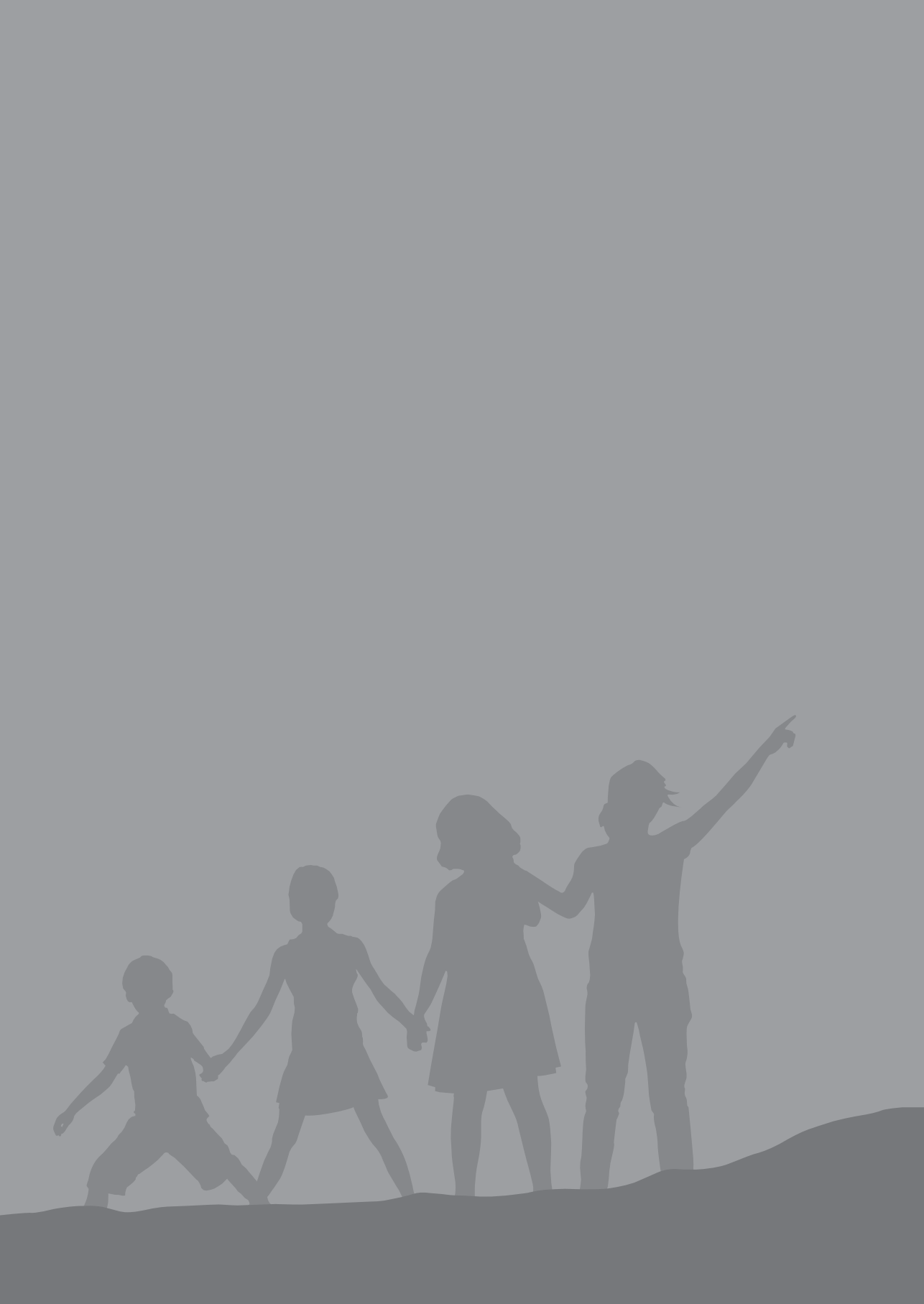
7

General discussion



The main purpose of the present research was to evaluate the data collected by various European countries in school years 2007/2008 and 2009/2010 as part of the European Childhood Obesity Surveillance Initiative (COSI) of the World Health Organization (WHO). These data were collected as a response to the 2006 WHO European Ministerial Conference on Counteracting Obesity[1] to allow countries to show visible progress in curbing the childhood obesity epidemic in the short-term and to use follow-up data for regular evaluations of their obesity preventive policies and actions[2] in the longer term. The main data explored for the present research were the weight and height measurements of children, 18 school environmental characteristics related to nutrition and physical activity, and children's lifestyle behaviours related to food consumption frequency, physical activity, screen time and sleep duration.

The following is a general reflection on the main findings in the context of the five thesis research questions as presented in the Introduction Chapter. Subsequently, it delves into methodological considerations related to COSI characteristics such as sampling design, data collectors and use of body mass index (BMI) as a measure for adiposity and the questionnaires applied. Furthermore, implications of the COSI data are put in a national context, as well as in an international context. This chapter finishes with some suggestions on how to go forward with COSI.

MAIN FINDINGS

The first research question referred to the magnitude of the problem of overweight and obesity among primary-school children in European countries and was addressed in Chapters 2 and 3. In school years 2007/2008 and 2009/2010, all countries' mean BMI-for-age (BMI/A) Z-score values, in both sexes and in all four targeted age groups, were found to be positive and thus higher than the population median values of the 2007 age- and gender-specific WHO growth reference[3]. This means that on average the COSI children aged 6–9 years were heavier than the reference population of the same age. Some countries even had mean BMI/A Z-score values close to or above +1, which is the 2007 WHO cut-off threshold for overweight in children and adolescents aged 5–19 years[3]. These are worrisome findings because the defined WHO cut-off threshold values for overweight and obesity are suggested to be associated with a range of cardiovascular risk factors in children and adolescents[4–6].

Regarding the second research question ("Does overweight and obesity prevalence differ by country and by European region?"), the data collected in both school years showed a wide range in overweight and obesity prevalence estimates that differed significantly by country, as well as by European region (Chapters 2 and 3). The findings indicate that, in all countries in both school years, the percentage of overweight children was about 20% or more, and the

percentage of obese children was 5% or more (based on WHO criteria[3]). The multi-country comparisons of the mean BMI values and prevalence estimates suggest the presence of two major groups of countries; countries were more or less comparable within each group, but with significant differences between the two groups. The group of countries with the highest prevalence estimates were mainly situated in southern Europe, namely Greece, Italy, Malta, Portugal, and Spain. In these countries, at least 30% of children were overweight, and at least 12% were obese. These findings confirm that overweight and obesity among 6–9-year-old children are a serious public health concern in European countries, and show the need for accelerated efforts to prevent excess body weight early in life.

The WHO classification for overweight (BMI ≥ 25.0 kg/m^2) and obesity (BMI ≥ 30.0 kg/m^2) in adults[7,8] has been based on an optimum population median BMI range of 21–23 kg/m^2 that is associated with the lowest health risks (both mortality and morbidity) related to BMI in adults[7–9]. This optimum range has been determined at which the chances of the presence of substantial proportions of either underweight or overweight people in the population are minimized[9]. At the upper limit of the range of the optimum BMI level of 23 kg/m^2, the minimum proportion of overweight people in the adult population is found to be nearly 20%[9]. The 2007 WHO growth reference[3] closely coincides with this adult WHO classification at the age of 19 years but is not based on an optimum population median BMI level associated with the lowest health risks (both mortality and morbidity) in children and adolescents. In the absence of a theoretical-minimum-risk distribution of BMI in children, the assumption is that the maximum proportion of overweight children in this distribution would also amount to 20%. This means that a stabilization of the overweight levels of more than 20% in the COSI countries, a trend that has been noted by recent studies[10–12], will not be sufficient in order to reach optimum population levels.

The third research question asks whether a change in overweight and obesity prevalence in a country might indeed be observed within a time interval of only 2–3 years (Chapter 3). Countries with higher prevalence of overweight in school year 2007/2008 (e.g. Italy and Portugal) showed the highest decrease in prevalence in school year 2009/2010, but still had among the highest estimates in that school year. Countries with lower prevalence in school year 2007/2008 (e.g. Latvia and Norway) showed the highest increase, but still had a lower prevalence estimate than the countries that showed the highest decrease. The Global Monitoring Framework on Maternal, Infant and Young Child Nutrition strongly suggests collecting data on weight and height in children and adolescents at least every 5 years[13]. According to the findings of the two rounds and the number of children sampled per country, it is possible to detect relevant changes over a shorter period of 2–3 years. However, when countries are unable to participate in every consecutive COSI round (e.g. Bulgaria and Sweden participated only in the first round), these countries would then still be able to adhere to the collection frequency of 5 years.

Chapters 4 and 5 highlight the role of the school nutrition environment (Chapter 4) and the role of the child's lifestyle behaviours on nutrition and physical activity (Chapter 5) in the occurrence of overweight and obesity in European countries (fourth research question). For the analyses of both groups of exposure variables, a score approach was applied. A categorization of the countries according to their mean school nutrition environment score (Chapter 4) did not reveal the same two clusters of countries as with the categorization based on the level of overweight. Both the cluster of countries with lower school nutrition environment scores and the cluster of countries with higher scores included countries with high overweight prevalence estimates. Hence, a significant association between the level at which a school supports a healthy nutrition environment and mean school BMI/A Z-score could not be demonstrated except for Norway and Sweden, although in opposite directions. The data on children's lifestyle behaviours (Chapter 5) could also not provide explanatory suggestions to the overweight north–south gradient found in Chapters 2 and 3. This might be due to the limited number of five countries that collected these data. A significant variation in the level of the risk behaviour scores could be shown across countries. This may lead to different prioritization of policy actions for each country[14].

To answer the fifth research question on the required level of standardization in data collection, two data collection practices were chosen for which the COSI protocol permitted flexibility and thus consequently a variation in their implementation level across countries (Chapter 6). The type of clothing worn by the children during the anthropometric measurements had an impact on the outcome measures, in particular on the mean BMI/A Z-score values. Therefore, adjusting the body weight for the weight of the clothes worn has to be maintained. The second data collection practice concerns the timing of the survey and the duration of the anthropometric measurements. Both aspects had little impact on the outcome measures in the two COSI rounds in school years 2007/2008 and 2009/2010, and it appears that no adjustments have to be made in the data analysis. It has been suggested that other methodological factors or data collection practices may also have an impact on anthropometric outcome measures. For instance, the number of field workers that have been involved in the measurements may affect the inter-observer measurement error[15,16] or the end-digit preference in the rounding of weight measurements may affect variation in BMI/A Z-score values[17]. All examiners had been instructed on how to measure the children, and the scales that were used recorded the weight with one decimal. It is thus unlikely that these factors have led to a bias in the presented national estimates.

METHODOLOGICAL CONSIDERATIONS

Sampling design

Countries that participated in the first round (school year 2007/2008) could decide for the next school year round 2009/2010 to select a new nationally representative sample of schools or to return to the same schools selected in the first round and randomly select classes from these sentinel sites. Four countries (Ireland, Lithuania, Norway and Portugal) chose the sentinel site approach and four (Czech Republic, Italy, Latvia and Slovenia) used newly recruited nationally representative samples in the second round[18]. At the start of COSI, it was assumed that a sentinel site approach would allow data gathering on a regular basis with limited human and financial resources. Yet, three of the four countries that went to the same schools in the second round reported that insufficient resources were still a main obstacle experienced with implementing COSI[18].

A disadvantage of the use of a sentinel site approach might be the continuous burden on the same local school health system, which then may lead to a low school participation rate. This was not observed in the four countries in school year 2009/2010 (range: 80–97%; Chapter 3). Given the strong focus during the last decade on the introduction of obesity preventive interventions in schools[19] and initiatives against childhood obesity in communities[20], another concern with the sentinel approach might be that the inclusion of the same schools over time may result in less representativeness of the 'true' prevalence of overweight. The COSI school form includes a question on the organization of school initiatives to promote a healthy lifestyle (e.g., to promote physical activity and/or healthy eating) during the school year surveyed (Chapter 4). Portugal showed a significant increase in the proportion of initiatives organized in school year 2007/2008 (64%) and 2009/2010 (92%), whereas the proportions in the other three countries remained similar. The significant increase observed in the Portuguese schools was likely due to the rollout of various school projects throughout the country and thus not because of the introduction of interventions specifically in these schools. Despite these reassuring findings, drawing new samples of schools in any future COSI rounds is advisable because we cannot assume that when a policy is introduced in a country to support a healthy nutrition environment in schools that it is then implemented in every school at the same level (if at all).

Data collectors

Countries could chose the most appropriate professionals to take the weight and height measurements of children. These professionals included school nurses, physicians or paediatricians linked to the school health system, other suitable school personnel such as physical education teachers, health professionals as part of health screening routines for all schoolchildren or specifically recruited for the data collection[18]. These categories of

professionals have also been reported as the main examiners in other growth monitoring systems[21,22]. Because all COSI examiners received instructions on the weight and height measurements according to standardized techniques, it is unlikely that the choice for a specific category of professionals may have had an impact on the results. This could, however, not be verified because in most cases sessions to standardize the measurements among examiners were not performed by countries (although it was asked for in the COSI protocol).

The school form was completed by school personnel (sometimes in the presence of the COSI examiner), mainly by the school principal or by the teachers involved with the sampled classes[18]. In an evaluation of the implementation of COSI during the school years 2007/2008 and 2009/2010, whereby the strengths, weaknesses, opportunities and threats (SWOT) technique was applied, concerns were raised about the burden placed on school personnel because other programmes were run at the same time as COSI[18]. Therefore, it was recommended that in future rounds the examiners should take over the school form completion from school personnel. To what extent this burden has really influenced the completion of the form is not clear, since the form was completed by > 99% of the sampled schools in the countries that applied the school form in both rounds. This high completion rate may be interpreted as a strong commitment by the schools, in particular for those countries that specifically reported the good collaboration with schools as one of the strengths of COSI in the SWOT evaluation[18].

Information on children's lifestyle behaviours was reported by the caregivers alone or jointly with their child on a so-called 'family record form'. To what extent a possible reporting bias[23,24] (i.e. over reporting of more favourable behaviours and underreporting of less favourable behaviours) has influenced the results is unknown. It would be helpful if the use of these proxy respondents in COSI is studied in more detail, in particular because of the noted reluctance of some parents to provide answers to socioeconomic-related questions such as income and the type of house in which the family lives[18].

Anthropometric measures

Anthropometric measures, such as subcutaneous skinfolds, weight, height and body circumferences, are less precise and accurate to assess the excess of body fat than some laboratory methods (i.e. body densitometry making use of underwater weighing), but they are more practical and easier to use in surveying children, both at the individual and population levels[8,25]. The use of skinfold thickness measurements within COSI has not been considered mainly because of its high inter-examiner variability, which would have required extensive training and standardization sessions[25,26]. The core measures within COSI are weight and height because they are relatively simple to measure, but the anthropometric indices derived from these measures are often considered more useful than the measures alone[8,25]. BMI is a measure of weight for height that is a well-recognized tool in determining whether a child may be thin, normal weight, at risk for overweight, overweight or obese[8,25]. When body

weight and body height are measured by a trained person, BMI is more accurate than when self-reported[27,28] or reported by parents[29,30], since people tend to underreport their own body weight (especially the obese) and to over report body height. However, BMI provides only a crude measure of body fatness, because it does not distinguish between weight associated with muscle and weight associated with fat[7,25]. The measurement of abdominal adiposity is essential because studies have shown, mainly in adults, that its excess (independently of total body fat) is strongly associated with measures of metabolic diseases and risk factors[31]. Hence, on a voluntary basis, the measurement of waist circumference was included in the COSI protocol, which was applied by few countries[32,33].

Validation of the school and child's behaviour questionnaires

Both the school form and the family record form have not really had their content validated at the time of their development in 2007. The school form was not based on validated questionnaires, but a draft version of the COSI form was pilot-tested on its comprehensibility in some of the participating countries prior to the first data collection in school year 2007/2008. The family record form that included questions on children's behaviours was adapted from the questionnaire of the 2001/2002 round of the Health Behaviour in School-aged Children (HBSC) survey[34] that was validated among adolescents[35]. The two COSI forms have, however, not been assessed, for instance, on their criterion validity, which examines the extent to which a measure provides results consistent with a gold standard[36]. This gold standard for the types of forms used in COSI is to our knowledge not available. Instead, a combination of different methods could be applied in future research that would indirectly measure their criterion validity. For instance, an option would be face-to-face validation interviews[37,38] with school personnel who completed the school form and with caregivers who filled out the family record form. In such interviews, the questions asked are structured and highly similar to those asked in the forms and are conducted relatively quickly after completion of the forms[39]. Direct observation in the schools would be another suitable method to validate the completion of the school form[37] and the completion of some of the questions in the family record form (e.g. home availability of certain food items)[40].

IMPLICATIONS OF THE FINDINGS

National context

Monitoring of progress of BMI reduction on a long-term basis is essential, as the outcomes in terms of reduced obesity and the related disease burden will take time to manifest. The incorporation of monitoring and evaluation in every policy or programme would contribute to the establishment of evidence-based public health[41]. Moreover, the use of a consistent

approach to population-level monitoring, such as the common COSI protocol, is likely to be useful in providing epidemiological data and guiding planning and resource allocation for preventative and general health promotion strategies[42]. The abovementioned SWOT analysis[18] revealed that COSI data have, for instance, been used as a source to develop national nutrition or obesity action plans, policies or programmes or national health strategies in several countries[43–45].

The monitoring results have also provided a basis for programmes for the prevention and control of overweight in school-aged children or for health promotion plans in health regions[18] or could be linked to health records at birth so that important ages for the onset of overweight and obesity could be identified[46]. This is an important achievement because the monitoring of incidence and remission rates over time is valuable for identifying the target groups for prevention and intervention at the local level before overweight becomes established[47]. Knowing the time of onset will also permit accounting for the duration of obesity in studies of trajectories and health impact[48].

COSI has helped to keep childhood obesity as a high priority on the political agenda in some countries, and COSI data are considered the official data on childhood prevalence of overweight and obesity by national authorities[18,49].

International context

Since its initiation in 2007 until to date, COSI is the only source of data that provide nationally representative overweight prevalence estimates in primary-school children that can also be used for comparisons between countries in Europe. Because of the repeated measurement rounds, COSI is also a source to document changes in prevalence estimates. The data collected in the 'Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study' is another important source that describes the distribution of the weight and BMI level in children below the age of 10 years over time across various European countries, but the samples drawn in that study are subnational[50].

The COSI overweight and obesity data have been a source for secondary analyses such as the Global Burden of Disease Study 2013[51] and have been included in overviews of overweight estimates[10]. They will also feed into international monitoring frameworks such as the Global Monitoring Framework on Maternal, Infant and Young Child Nutrition[13] and the Global Monitoring Framework for the prevention and control of Noncommunicable Diseases (NCDs)[52]. Additionally, the COSI overweight and obesity prevalence estimates have been mentioned as a source for the monitoring of European action plans like, for example, the *Vienna Declaration on Nutrition and NCDs in the Context of Health 2020*[53], the *European Union Action Plan on Childhood Obesity 2014–2020*[54] and the *European Food and Nutrition Action Plan 2015–2020*[55].

THE WAY FORWARD

The establishment of COSI can be considered as the start of population-based monitoring of overweight and obesity among primary-school children (based on measured data) in Europe. At each data collection round, the core objective is to measure in a new cross-sectional sample of primary-school children their weight and height and to derive relevant indices, including BMI, as well as prevalence estimates of overweight and obesity. Countries have the choice of expanding these core anthropometric measurements with the collection of data on e.g. the children's waist circumference, their food frequency consumption, physical activity and sedentary behaviours, as well as with information on school nutrition environmental characteristics. The COSI protocol was developed in 2007. It was then based on the literature and survey protocols available at that time. Since then, several European research projects have been implemented with the aim to assess the overweight status of children and adolescents, as well as its determinant factors[50,56–58]. It is recommended to synchronize the COSI family record form with the components of these European project protocols that aimed to measure the same outcome as COSI. In addition, the work done by HBSC[59], the Schools for Health in Europe Network[60], the WHO framework for health promoting schools[61–63], the school policy framework developed by WHO[64], as well as the framework developed by, for instance, L'Abbé *et al*.[65] would all be valuable sources to review and see which components could be included in the COSI school form.

The results presented in this thesis concern the first two school year rounds (2007/2008 and 2009/2010). In the meantime, the third data collection round (school year 2012/2013) finished (not yet elaborated and published), and the fourth data collection round (school year 2015/2016) is in preparation. In 2015, WHO started initiatives to review the school and family questionnaire forms, taking into account the experiences with these forms up to now.

A strong relationship exists between obesity in European children and the socioeconomic status of their parents[66,67]. The COSI family record form includes questions on parental education, parental occupation, household income and housing and has been applied by just a few countries. Reducing health inequities is a key strategy in the European Region[68]. COSI could provide an excellent opportunity for the provision of data on socioeconomic inequities in terms of the children's physical status. However, in that case, the family record form should be filled out by many more (preferably all) participating COSI countries in order to obtain a valid justification on the socioeconomic groups that need to be specifically targeted by obesity preventive interventions[67].

CONCLUDING REMARKS

In summary, COSI has developed a common agreed international protocol for the monitoring of childhood obesity using standardized measurement techniques. It adds on to earlier initiatives[69] by enabling intercountry comparisons and providing comparative information on magnitude and trend. COSI was set up as a response to the need for international comparable data as stated in the 2006 *European Charter on Counteracting Obesity*[2]. The COSI data will now subsequently be used as outcome measures for the monitoring of the implementation of policy actions that are, for instance, mentioned in the *Vienna Declaration on Nutrition and NCDs in the Context of Health 2020*[53]. COSI data have been the source for policy development and revision and for preventive intervention planning in many of the participating COSI countries. The data have also been used in international analyses and will be a data source for the monitoring of international policy frameworks.

Governments are strongly committed to combat childhood overweight by promoting a healthy diet and encouraging physical activity, as shown by the many declared commitments since the nineties through the policy frameworks that are listed in the Introduction Chapter. Nevertheless, the COSI findings show that overweight levels in children remain high and call for accelerated efforts to tackle this public health problem. The continued efforts and data resulting from COSI will be instrumental in advancing national preventive policies in a wider international and global policy framework.

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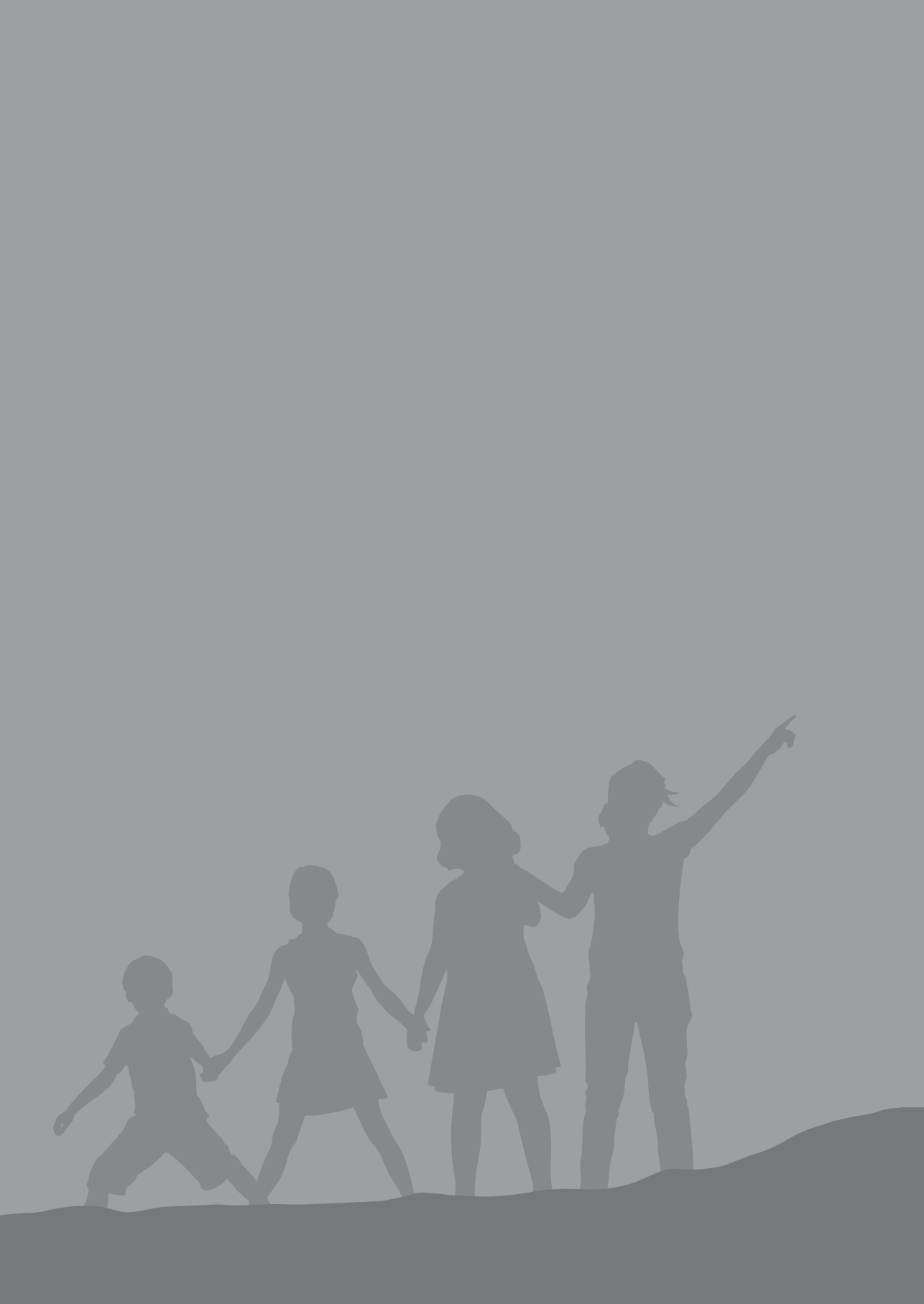
Summary / Samenvatting



The prevalence of obesity has more than doubled since the last three decades and to date, most of the world's populations live in countries where overweight and obesity lead to more deaths than underweight. Excess body weight in children and adolescents is also a main public health problem in the World Health Organization (WHO) European Region. Childhood obesity is associated with a higher risk of premature mortality, morbidity and disability in adulthood, but also with the onset of noncommunicable diseases earlier in life. To facilitate European-wide action on this emerging public health challenge, a European Ministerial Conference on Counteracting Obesity was convened on 15–17 November 2006 in Istanbul, Turkey.

In the process leading to this Conference, it was recognized that regular assessments of the magnitude of overweight and obesity at the national level, particularly in children and adolescents, are not common in the WHO European Region. One of the Member States recommendations to WHO included the establishment of a European-wide and standardized childhood surveillance system on which policy development could be based. Hence, the WHO European Childhood Obesity Surveillance Initiative (COSI) was launched in 2007 to enable tracking of changes over time of the prevalence of overweight and obesity among primary-school children aged 6–9 years and comparing nationally representative data between countries within the WHO European Region. This PhD thesis reports on intercountry analyses of the data collected in the first two COSI rounds that took place during the school years 2007/2008 and 2009/2010.

As the introduction, **Chapter 1** gives an overview of the magnitude of the prevalence of childhood overweight and obesity at the global and European levels, and an overview of their possible health consequences both early and later in life. Furthermore, **Chapter 1** provides examples of global and European policies and action plans that include childhood overweight prevention as one of their main goals or address priority actions to tackle it. Moreover, the importance of monitoring levels of overweight is addressed and examples of monitoring systems in European countries are given. Finally, **Chapter 1** describes the initiation and implementation processes of COSI and lists the five research questions addressed in this PhD thesis.

Chapter 2 presents the anthropometric results, based on measured weight and height, of the first COSI data collection round during school year 2007/2008 from 12 countries: Belgium, Bulgaria, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden. A total of 168 832 children aged 6–9 years were included in the data analyses (85 934 boys and 82 898 girls). The prevalence of overweight ranged from 19.3% to 49.0% among boys and from 18.4% to 42.5% among girls; 6.0–26.6% of boys and 4.6–17.3% of girls were obese. The multi-country comparisons of the prevalence estimates suggest the presence of a north–south gradient with the highest level of overweight found in southern European countries, in particular in Italy, Malta, Portugal and Slovenia. Their prevalence estimates differed statistically significantly from almost all other participating

countries. The results presented in **Chapter 2** confirm that overweight among 6–9-year-old children is a serious public health concern in European countries and that its variation across the WHO European Region highly depends on the country.

Chapter 3 reports on the anthropometric results, based on measured weight and height, of the second COSI data collection round during school year 2009/2010 from 13 countries: Belgium, Czech Republic, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Portugal, Slovenia, Spain, and the former Yugoslav Republic of Macedonia. A total of 224 920 children aged 6–9 years were included in these data analyses (114 457 boys and 110 463 girls). The prevalence of overweight ranged from 18.0% to 57.2% among boys and from 18.2% to 50.0% among girls; 5.8–30.5% of boys and 5.2–20.8% of girls were obese. Like in school year 2007/2008, the findings from school year 2009/2010 also suggest the presence of a north–south gradient with the highest overweight and obesity prevalence estimates noted in southern European countries. **Chapter 3** also shows the direction and magnitude of the change in mean anthropometric values, as well as in overweight and obesity prevalence estimates from school year 2007/2008 to school year 2009/2010 within nine countries that participated in both COSI rounds. Between rounds, the absolute change in prevalence of overweight (range: from –9.0% to +6.2%) and prevalence of obesity (range: from –3.9% to +4.2%) varied statistically significantly across countries. The highest significant decrease in overweight prevalence was found in countries with higher absolute body mass index (BMI) values in school year 2007/2008 (e.g. Italy, Portugal and Slovenia); the highest significant increase occurred in countries with lower BMI values (e.g. Latvia and Norway). It could be that active implementation of policies or interventions to counteract overweight and obesity have been triggered more by the countries with higher values in school year 2007/2008 than the countries with lower values.

Chapter 4 focuses on the findings of the COSI mandatory school form that was administered in the selected schools (1831 in school year 2007/2008 and 2045 in school year 2009/2010) in 12 countries to collect information on the frequency of 18 school environmental characteristics on nutrition and physical activity. These 12 countries were: Bulgaria, Czech Republic, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden. A school nutrition environment score was calculated using five nutrition-related characteristics whereby higher scores correspond to higher support for a healthy school nutrition environment. A large variation was found between the countries in the availability of food items or beverages on the school premises (e.g., fresh fruit could be obtained in 12–95% of schools) and in the organization of initiatives to promote a healthy lifestyle in the selected classes (ranging from 42% to 97%). The provision of physical education lessons and the availability of school playgrounds were more uniformly present across the countries (ranging from 76% to 100%). Countries with a low school nutrition environment score (Bulgaria, Czech Republic, Greece, Hungary, Latvia and Lithuania) graded less than three

out of five characteristics as supportive. High-score (≥ 0.70) countries were Ireland, Malta, Norway, Portugal, Slovenia and Sweden. The combined absence of cold drinks containing sugar, sweet snacks and salted snacks were more observed in high-score countries than in low-score countries. The data in **Chapter 4** suggest that some European countries have implemented more school policies that are supportive to a healthy nutrition environment than others. However, most countries with low school nutrition environment scores also host schools with supportive school environment policies, suggesting that a uniform school policy to tackle the 'unhealthy' school nutrition environment has not been implemented at the same level throughout a country and may underline the need for harmonized school policies.

Chapter 5 refers to the findings of the use of the COSI voluntary family record form by Bulgaria, Czech Republic, Lithuania, Portugal and Sweden in school year 2007/2008, which gathers information on children's lifestyle behaviours related to breakfast and food consumption frequency, physical activity, screen time and sleep duration, as well as data on parental education and parental occupation. A total of 15 643 children were included in the analysis. The presence of 13 defined behavioural health risks among the children was examined, as well as the association between these health-risk behaviours, individually or combined, and overweight and obesity. The highest prevalence of many risk behaviours was observed in Bulgaria and the lowest in Sweden, whereas the other three countries did not show a clear country order ranking pattern across the behaviours. Not having breakfast daily and ≥ 2 hours/day screen time were clearly positively associated with obesity. The same was true for eating 'foods like pizza, French fries, hamburgers, sausages or meat pies' > 3 days/week and playing outside < 1 hour/day. Other individual unhealthy eating or less favourable physical activity behaviours showed either no or significant negative associations with obesity. The significant positive associations described in **Chapter 5** between a combination of multiple less favourable physical activity behaviours and obesity underline the importance of the promotion of physical activity-related and the discouragement of sedentary behaviours among schoolchildren in the context of obesity preventive interventions. A combination of the presence of multiple unhealthy eating behaviours did not lead to higher odds of obesity.

Allowing participating countries to adhere to their local legal requirements or adapt to other circumstances required developing a flexible COSI protocol for the anthropometric procedures. **Chapter 6** reviews for both COSI rounds the intercountry variation observed in types of clothing worn by the children during weight and height measurements, clothes weight adjustments applied, timing of the survey and duration of data collection. Moreover, it examines the impact of these observed intercountry differences on the estimates of countries' mean age-adjusted Z-score values of children's weight or BMI, as well as on the countries' prevalence estimates of overweight or obesity. The clothes-adjusted overweight prevalence estimates were relatively lower by as much as 12% than the unadjusted estimates, and the clothes-adjusted obesity prevalence estimates were relatively lower by as much as 10% than

the unadjusted estimates. The relative difference between unadjusted and country-specific clothes-adjusted mean BMI-for-age Z-score values was 6–33%. Monthly fluctuations in mean BMI-for-age Z-score values did not show a systematic seasonal effect. The majority of the monthly BMI-for-age Z-score values did not statistically differ within a country; only 1–3 monthly values were statistically different within some countries. The findings shown in **Chapter 6** suggest that the built-in flexibility in the COSI protocol concerning the data collection practices addressed can be kept and thus do not necessitate a revision of the COSI protocol.

Finally, as the general discussion of this PhD thesis, **Chapter 7** summarizes the main findings in the context of the five research questions, discusses some methodological issues related to the COSI study design, provides examples of the way the data are used in national and international contexts and gives suggestions on the way forward. Although a decrease was observed in some countries from school year 2007/2008 to school year 2009/2020 in overweight and obesity, the prevalence estimates are still high and show the need for accelerated efforts to prevent excess body weight early in life. COSI data have been the source for policy development and revision and for preventive intervention planning. The data have also been used in international analyses and will be used to monitor international policy frameworks. The COSI protocol was developed in 2007, and literature and survey protocols available at that time were consulted. Since then, many European projects have been implemented in the field of obesity and developed similar survey protocols. It would be recommended to align the COSI questionnaires with relevant components of their survey protocols. In addition, the inclusion of variables on socioeconomic inequities in the mandatory COSI questionnaires may be considered.

De prevalentie van obesitas is de laatste drie decennia meer dan verdubbeld, en vandaag de dag woont het grootste deel van de wereldbevolking in landen waar overgewicht en obesitas tot meer sterfgevallen leiden dan ondergewicht. Overmatig lichaamsgewicht bij kinderen en adolescenten is ook een belangrijk volksgezondheidsprobleem in de Europese regio van de Wereldgezondheidsorganisatie (WHO). Obesitas bij kinderen wordt in verband gebracht met een hoger risico op voortijdig overlijden, ziekte en arbeidsongeschiktheid op volwassen leeftijd, maar ook met het ontstaan op jongere leeftijd van niet-overdraagbare ziekten. Om Europese maatregelen ten aanzien van deze nieuwe uitdaging voor de volksgezondheid te faciliteren, vond er van 15–17 november 2006 in Istanboel, Turkije een Europese ministeriële conferentie plaats over de bestrijding van obesitas.

In het proces dat tot deze conferentie heeft geleid, werd erkend dat regelmatige beoordelingen van de mate van overgewicht en obesitas op nationaal niveau, met name bij kinderen en adolescenten, in de Europese regio van de WHO helemaal niet gebruikelijk zijn. Eén van de aanbevelingen van de lidstaten aan de WHO was dan ook de oprichting van een Europa-breed, gestandaardiseerd, op kinderen gericht surveillancesysteem op basis waarvan beleid kan worden ontwikkeld. Derhalve werd in 2007 het WHO European Childhood Obesity Surveillance Initiative (COSI) gelanceerd om inzicht te krijgen in hoeverre de prevalentie van overgewicht en obesitas bij basisschoolkinderen tussen de 6–9 jaar in de tijd verandert en om vergelijkingen te kunnen maken tussen de nationaal representatieve gegevens van de verschillende landen binnen de Europese regio van de WHO. In dit proefschrift wordt verslag gedaan van de interlandelijke analyses van de gegevens die in de eerste twee COSI-ronden, tijdens de schooljaren 2007/2008 en 2009/2010, werden verzameld.

Als inleiding wordt in **hoofdstuk 1** een overzicht gegeven van de mate van overgewicht en obesitas bij kinderen op mondiaal en Europees niveau en daarnaast wordt er een overzicht gegeven van de eventuele gevolgen daarvan voor de gezondheid, zowel op jonge als op latere leeftijd. In **hoofdstuk 1** worden bovendien voorbeelden gegeven van mondiale en Europese beleidsmaatregelen en actieplannen die de preventie van overgewicht bij kinderen als een van hun belangrijkste doelstellingen hebben of die prioritaire maatregelen nemen om dit probleem aan te pakken. Daarnaast wordt gekeken naar het belang van het monitoren van de omvang van overgewicht en worden er voorbeelden van monitoringssystemen in Europese landen gegeven. Tot slot worden in **hoofdstuk 1** de in- en uitvoeringsprocessen van COSI beschreven en worden de vijf onderzoeksvragen geïntroduceerd die in dit proefschrift worden behandeld.

In **hoofdstuk 2** zien we de antropometrische resultaten, gebaseerd op gemeten gewicht en lengte, van de eerste COSI-gegevensverzamelingsronde gedurende het schooljaar 2007/2008 in 12 landen: België, Bulgarije, Ierland, Italië, Letland, Litouwen, Malta, Noorwegen, Portugal, Slovenië, Tsjechië en Zweden. In totaal werden er 168.832 kinderen tussen de 6–9 jaar in de gegevensanalyses opgenomen (85.934 jongens en 82.898 meisjes).

De prevalentie van overgewicht varieerde van 19,3% tot 49,0% bij jongens en van 18,4% tot 42,5% bij meisjes; 6,0–26,6% van de jongens en 4,6–17,3% van de meisjes had obesitas. De interlandelijke vergelijkingen van de prevalentieschattingen wijzen op de aanwezigheid van een noord-zuid gradiënt waarbij de hoogste mate van overgewicht in de zuidelijke Europese landen wordt waargenomen, met name in Italië, Malta, Portugal en Slovenië. De prevalentieschattingen van deze landen verschilden statistisch significant van bijna alle andere deelnemende landen. De resultaten die in **hoofdstuk 2** worden gepresenteerd, bevestigen dat overgewicht onder kinderen tussen 6–9 jaar oud in Europese landen een ernstig probleem vormt voor de volksgezondheid en dat de verschillen binnen de Europese regio van de WHO zeer landgebonden zijn.

In **hoofdstuk 3** zien we de antropometrische resultaten, gebaseerd op gemeten gewicht en lengte, van de tweede COSI-gegevensverzamelingsronde gedurende het schooljaar 2009/2010 in 13 landen: België, Griekenland, Hongarije, Ierland, Italië, Letland, Litouwen, Noorwegen, Portugal, Slovenië, Spanje, Tsjechië en de voormalige Joegoslavische Republiek Macedonië. In totaal werden er 224.920 kinderen tussen de 6–9 jaar in de gegevensanalyses opgenomen (114.457 jongens en 110.463 meisjes). De prevalentie van overgewicht varieerde van 18,0% tot 57,2% bij jongens en van 18,2% tot 50,0% bij meisjes; 5,8–30,5% van de jongens en 5,2–20,8% van de meisjes had obesitas. Net als in het schooljaar 2007/2008 wijzen ook de bevindingen van het schooljaar 2009/2010 op een noord-zuid gradiënt waarbij de hoogste prevalentieschattingen van overgewicht en obesitas in de zuidelijke Europese landen werden geregistreerd. **Hoofdstuk 3** toont ook de richting en omvang van de verandering van het schooljaar 2007/2008 tot het schooljaar 2009/2010, zowel in gemiddelde antropometrische waarden als in prevalentieschattingen van overgewicht en obesitas, in de negen landen die aan beide COSI-ronden deelnamen. Tussen de ronden was er sprake van een statistisch significante absolute verandering in de prevalentie van overgewicht (bereik: van –9,0% tot +6,2%) en de prevalentie van obesitas (bereik: van –3,9% tot +4,2%) in de landen. De grootste significante daling in de prevalentie van overgewicht werd waargenomen in landen met hogere absolute body mass index (BMI) -waarden in het schooljaar 2007/2008 (bijv. Italië, Portugal en Slovenië); de grootste significante stijging vond plaats in landen met aanvankelijk lagere BMI-waarden (bijv. Letland en Noorwegen). Het is mogelijk dat de landen die in het schooljaar 2007/2008 hogere BMI-waarden noteerden, meer gemotiveerd waren om te starten met de actieve uitvoering van beleidsmaatregelen of interventies om overgewicht en obesitas te bestrijden, dan de landen met lagere waarden.

Hoofdstuk 4 richt zich op de bevindingen van het verplichte COSI-schoolformulier dat in de geselecteerde scholen in 12 landen werd uitgedeeld (1831 in het schooljaar 2007/2008 en 2045 in het schooljaar 2009/2010) om informatie te verzamelen over de frequentie van 18 schoolomgevingskenmerken inzake voeding en lichaamsbeweging. Deze 12 landen waren: Bulgarije, Griekenland, Hongarije, Ierland, Letland, Litouwen, Malta, Noorwegen, Portugal,

Slovenië, Tsjechië en Zweden. Er werd een schoolomgevingsscore inzake voeding berekend aan de hand van vijf voedingsgerelateerde kenmerken, waarbij hogere scores overeenkwamen met meer ondersteuning voor gezonde voeding op school. Er werden grote verschillen tussen de landen waargenomen wat betreft de beschikbaarheid van voedsel en dranken op scholen (bijv. vers fruit kon worden verkregen in 12–95% van de scholen) en wat betreft de organisatie van initiatieven om een gezonde levensstijl in de geselecteerde klassen te promoten (variërend van 42% tot 97%). Lessen lichamelijke opvoeding en schoolpleinen waren in de verschillende landen veel uniformer aanwezig (variërend van 76% tot 100%). Landen met een lage schoolomgevingsscore inzake voeding (Bulgarije, Griekenland, Hongarije, Letland, Litouwen en Tsjechië) beoordeelden minder dan drie van de vijf kenmerken als ondersteunend. Landen met een hoge score (≥ 0,70) waren Ierland, Malta, Noorwegen, Portugal, Slovenië en Zweden. De gecombineerde afwezigheid van suikerhoudende koude dranken, zoete snacks en zoute snacks werd vaker in hoog scorende landen dan in laag scorende landen waargenomen. De gegevens in **hoofdstuk 4** doen vermoeden dat er in sommige Europese landen meer schoolbeleid is ingevoerd dat een gezonde voedingsomgeving ondersteunt dan in andere landen. In de meeste landen met lage schoolomgevingsscores inzake voeding bevinden zich echter ook scholen waarin het schoolomgevingsbeleid wel ondersteunend is. Dit wijst erop dat er geen sprake is van een uniform schoolbeleid ter bestrijding van een 'ongezonde' voedingsomgeving op school dat op hetzelfde niveau in het hele land is doorgevoerd. Dit onderstreept eens te meer het belang van geharmoniseerd schoolbeleid.

Hoofdstuk 5 gaat over de bevindingen inzake het gebruik van het vrijwillige COSI-gezinsregistratieformulier door Bulgarije, Litouwen, Portugal, Tsjechië en Zweden in het schooljaar 2007/2008. Op dit formulier wordt informatie ingevuld over de levensstijlgedragingen van het kind met betrekking tot frequentie van ontbijt en voedselconsumptie, lichaamsbeweging, beeldschermtijd en slaapduur, alsmede gegevens over het genoten onderwijs en de werksituatie van de ouders. Er werden in totaal 15.643 kinderen in de analyse opgenomen. Er werd gekeken naar de aanwezigheid van 13 omschreven gezondheidsrisicovolle gedragingen bij kinderen, en naar het verband tussen deze gezondheidsrisicovolle gedragingen, los en gecombineerd, en overgewicht en obesitas. De hoogste prevalentie van een groot aantal van de risicovolle gedragingen werd waargenomen in Bulgarije en de laagste in Zweden. De andere drie landen vertoonden geen duidelijke landvolgorde in de rangschikking tussen de verschillende gedragingen. Niet dagelijks ontbijten en ≥ 2 uur/dag beeldschermtijd werden duidelijk positief in verband gebracht met obesitas. Hetzelfde gold voor het eten van 'voedingsmiddelen zoals pizza, friet, hamburgers, worsten of vleespasteitjes' > 3 dagen/week en < 1 uur/dag buitenspelen. Andere individuele ongezonde eetgewoonten of minder gunstige lichaamsbewegingsgedragingen hadden ofwel geen ofwel een significant negatief verband met obesitas. De in **hoofdstuk 5** beschreven significant positieve verbanden tussen een combinatie van meerdere minder gunstige lichaamsbewegingsgedragingen en obesitas

onderstrepen hoe belangrijk het is om lichaamsbeweging bij schoolkinderen te stimuleren en sedentaire gedragingen te ontmoedigen in de context van maatregelen ter preventie van obesitas. Een combinatie van de aanwezigheid van meerdere ongezonde eetgedragingen leidde niet tot een hogere kans op obesitas.

Om deelnemende landen in staat te stellen te kunnen voldoen aan hun eigen lokale wettelijke regels of zich aan te passen aan andere omstandigheden, moest er een flexibel COSI-protocol voor de antropometrische procedures worden ontwikkeld. In **hoofdstuk 6** bespreken we voor beide COSI-ronden de verschillen tussen de landen die werden waargenomen wat betreft het soort kleding dat de kinderen droegen tijdens de gewichts- en lengtemetingen, de kledinggewichtcorrecties die werden toegepast, het seizoensmoment van het onderzoek en de duur van de gegevensverzameling. Bovendien onderzoeken we de impact die deze waargenomen verschillen tussen de landen hebben op de schattingen van de nationale gemiddelde leeftijdsgecorrigeerde standaarddeviatiescores (SDS) van het gewicht of de BMI van de kinderen, en op de nationale prevalentieschattingen van overgewicht of obesitas. De kledinggecorrigeerde overgewichtprevalentieschattingen waren relatief maar liefst 12% lager dan de niet-gecorrigeerde schattingen, en de kledinggecorrigeerde obesitasprevalentieschattingen waren relatief maar liefst 10% lager dan de niet-gecorrigeerde schattingen. Het relatieve verschil tussen de niet-gecorrigeerde en de kledinggecorrigeerde gemiddelde leeftijdsgecorrigeerde BMI-standaarddeviatiescores van de landen was 6–33%. Maandelijkse schommelingen in de gemiddelde leeftijdsgecorrigeerde BMI-standaarddeviatiescores lieten geen systematisch seizoensgebonden effect zien. De meeste maandelijkse leeftijdsgecorrigeerde BMI-standaarddeviatiescores vertoonden geen statistische verschillen binnen een land; slechts 1–3 maandelijkse scores vertoonden binnen sommige landen statistische verschillen. De bevindingen die in **hoofdstuk 6** worden gepresenteerd, wijzen erop dat de in het COSI-protocol ingebouwde flexibiliteit met betrekking tot de besproken gegevensverzamelingspraktijken gehandhaafd kan blijven en er derhalve geen herziening van het COSI-protocol nodig is.

Tot slot volgt in **hoofdstuk 7** de algemene discussie van dit proefschrift. In dit laatste hoofdstuk worden de belangrijkste bevindingen in de context van de vijf onderzoeksvragen samengevat, worden een aantal methodologische kwesties met betrekking tot de COSI-studieopzet besproken, worden voorbeelden gegeven van de manier waarop de gegevens in nationale en internationale contexten zijn gebruikt en worden suggesties gedaan voor de toekomst. Hoewel er van het schooljaar 2007/2008 tot het schooljaar 2009/2010 in sommige landen een daling werd waargenomen in de prevalentie van overgewicht en obesitas, zijn de prevalentieschattingen nog steeds hoog en tonen ze de noodzaak van versnelde inspanningen om overmatig lichaamsgewicht op jonge leeftijd te voorkomen. De COSI-gegevens hebben het fundament gelegd voor beleidsontwikkeling en -herziening en voor de planning van preventieve interventies. De gegevens zijn ook gebruikt voor internationale

analyses en zullen worden gebruikt om internationale beleidskaders te monitoren. Het COSI-protocol werd in 2007 ontwikkeld. Dat betekent dat men gebruik heeft gemaakt van de literatuur en onderzoeksprotocollen die op dat moment beschikbaar waren. Sindsdien zijn er vele Europese projecten op het gebied van obesitas uitgevoerd en zijn er even zo vele onderzoeksprotocollen ontwikkeld. Het is aan te raden de COSI-vragenlijsten op één lijn te brengen met relevante onderdelen van die onderzoeksprotocollen. Daarnaast zou kunnen worden overwogen variabelen inzake sociaaleconomische ongelijkheden in de verplichte COSI-vragenlijsten op te nemen.

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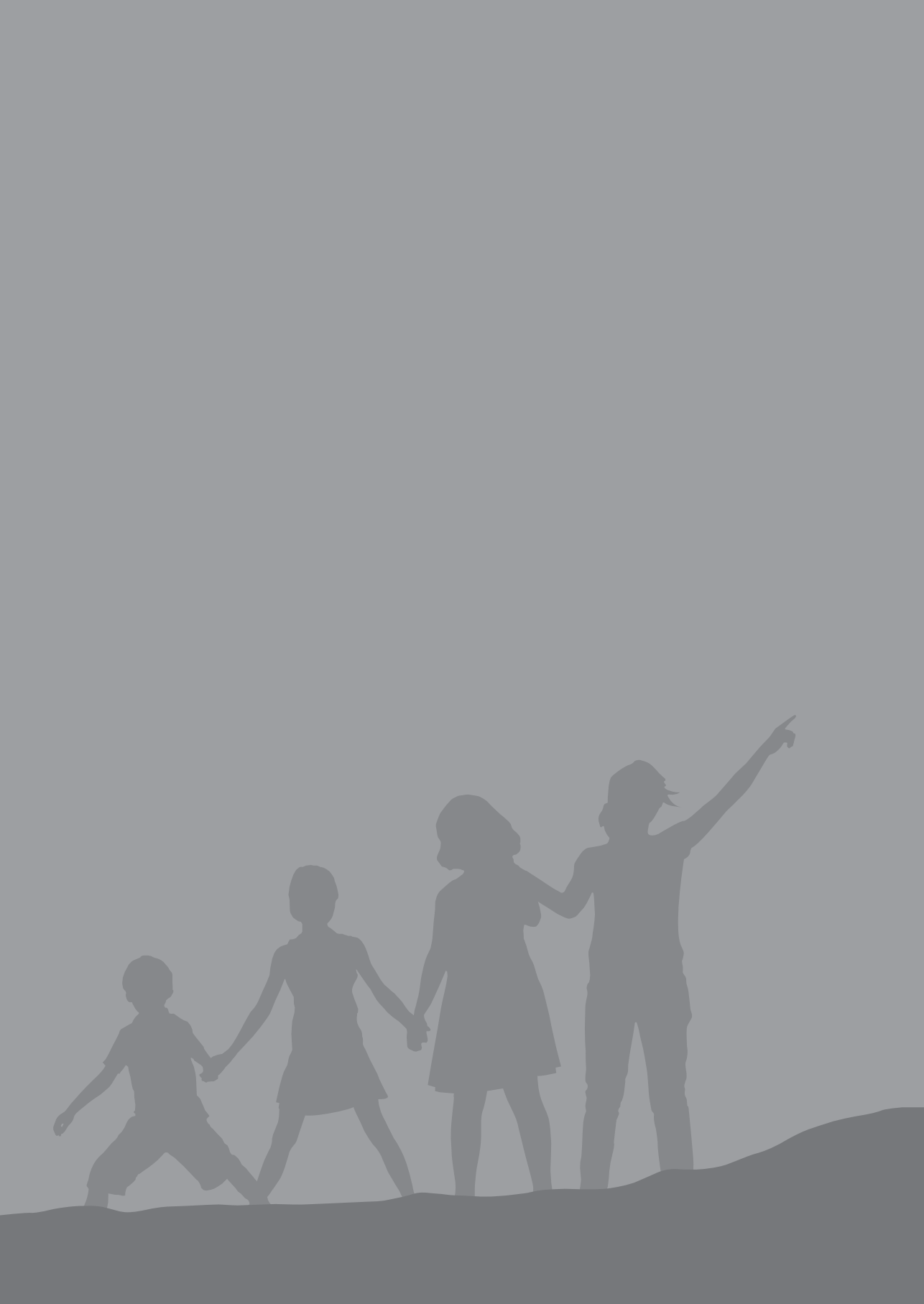

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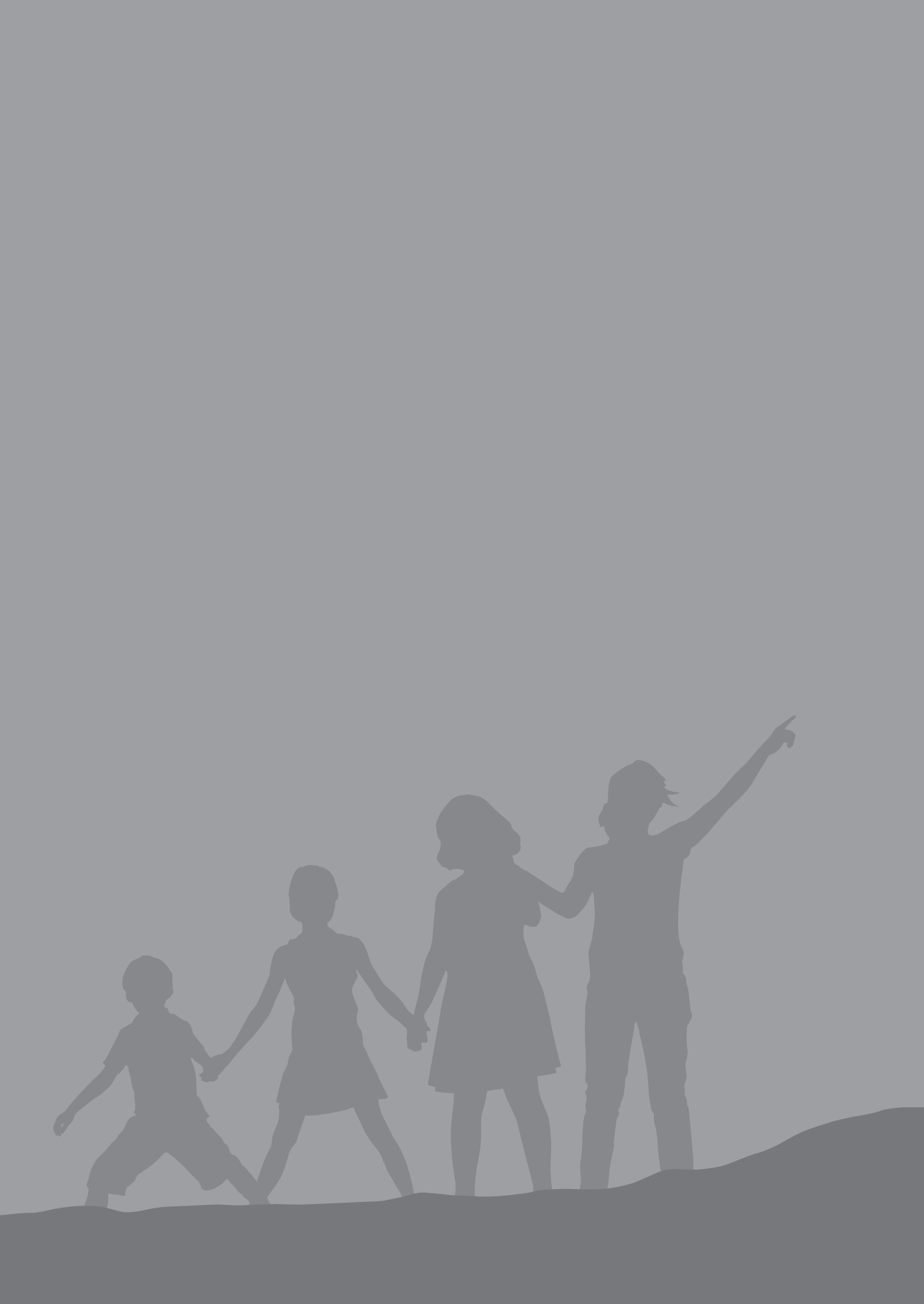

"*Lang gedacht, lang verwacht, lang gewacht*" (translated into English as "thought of for a long time, long expected, long awaited") are the words that have been in the back of my mind during my entire PhD trajectory that took more than eight years, and even before I officially started it in March 2007. I remember a particular moment when I, as a little girl, was filling in a crossword puzzle and I asked my father what the abbreviation 'dr' meant. He answered that this is the abbreviation for doctor. I then asked, "Someone who makes people better?" "No, this is someone who has written a piece about a topic that nobody worldwide has written about yet", he replied to me. And I could only think, "How is it possible that you can think of a topic that nobody has thought of yet and then write about it?" And thus now here we are.

A very long trajectory, but it was worth it, whereby many people have supported and guided me during these years. In this section, I would like to thank in particular those persons who have contributed to the professional content of my thesis, as well as to the administrative arrangements of the organization of the international meetings of the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI).

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The research described in this PhD thesis refers to the first and second COSI data collection rounds and is the result of a multicentre effort to which many people and institutions have contributed. I would like to express sincere appreciation, in particular, to the country principal investigators who have supported me in various ways during these two rounds. Without you I would not have succeeded in finishing this journey of eight years and, therefore, one of the propositions is for you to acknowledge your commitment, friendship and collegiality. In addition, I would like to express my gratitude to the members of the COSI Advisory Group for their valuable guidance and advice. A very special thank you goes to: Dr Usama Al-Ansari, Dr Edita Albaviciute, Dr A. Tülay Bağcı Bosi, Dr Christine Baluci, Dr Anna Biehl, Ms Lien Braeckevelt, Dr Radka Braunerova, Dr João Breda, Prof. Dr Genc Burazeri, Dr Angela Ciobanu, Ms Heidi Cloots, Dr Hywell Dinsdale, Prof. Dr Vesselka Duleva, Ms Bettina Ehrenblad, Dr Nazih Eldin, Dr Victoria Farrugia Sant'Angelo, Prof. Dr Pedro Graça, Prof. Maria Hassapidou, Dr Patricia Heavey, Dr Mirjam Heinen, Dr Ragnhild Hovengen, Dr Ciáran Humphreys, Dr Jolanda Hyska, Dr Vladimir Kendrovski, Dr Victória Kovács, Dr Marie Kunešová, Prof. Dr Lauren Lissner, Ms Eliza Markidou, Dr Éva Martos, Dr Kirsten Mehlig, Dr Jørgen Meisfjord, Dr Ehadu Mersini, Dr Lotta Moraeus, Prof. Dr Pedro Moreira, Dr Rodica Nicolescu, Ms Bente Nilsen, Dr Moe Thet Nyo, Dr Galina Obreja, Ms Ursula O'Dwyer, Dr John Osborn, Dr Napoleón Pérez-Farinós, Prof. Dr Ausra Petrauskiene, Prof. Dr Stefka Petrova, Mr Eric Poortvliet, Dr Iveta Pudule, Dr Joop van Raaij, Dr Ana Rito, Prof. Dr Inta-Mara Rubana, Dr Harry Rutter, Dr Antonella Sammut, Dr Marvic Sammut, Dr Christopher Scerri, Dr Agneta Sjöberg, Dr Angela Spinelli, Dr Igor Spiroski, Dr Gregor Starc, Ms Biruta Velika, Ms Machteld Wauters, Dr Nazan Yardim, and Prof. Dr Agneta Yngve.

I gave the first official presentation on the COSI protocol at the WHO European Ministerial Conference on Counteracting Obesity, which was convened on 15–17 November 2006 in Istanbul, Turkey. For the preparation of this presentation, I received great help and essential advice from Dr Margherita Caroli. Margherita, I will never forget this particular and very special moment for me when we were working on the slides during the middle of the night (the only moment that we could find time to sit together during the Conference) and for your encouragement through non-verbal signs during the session when I delivered this presentation. Thank you!

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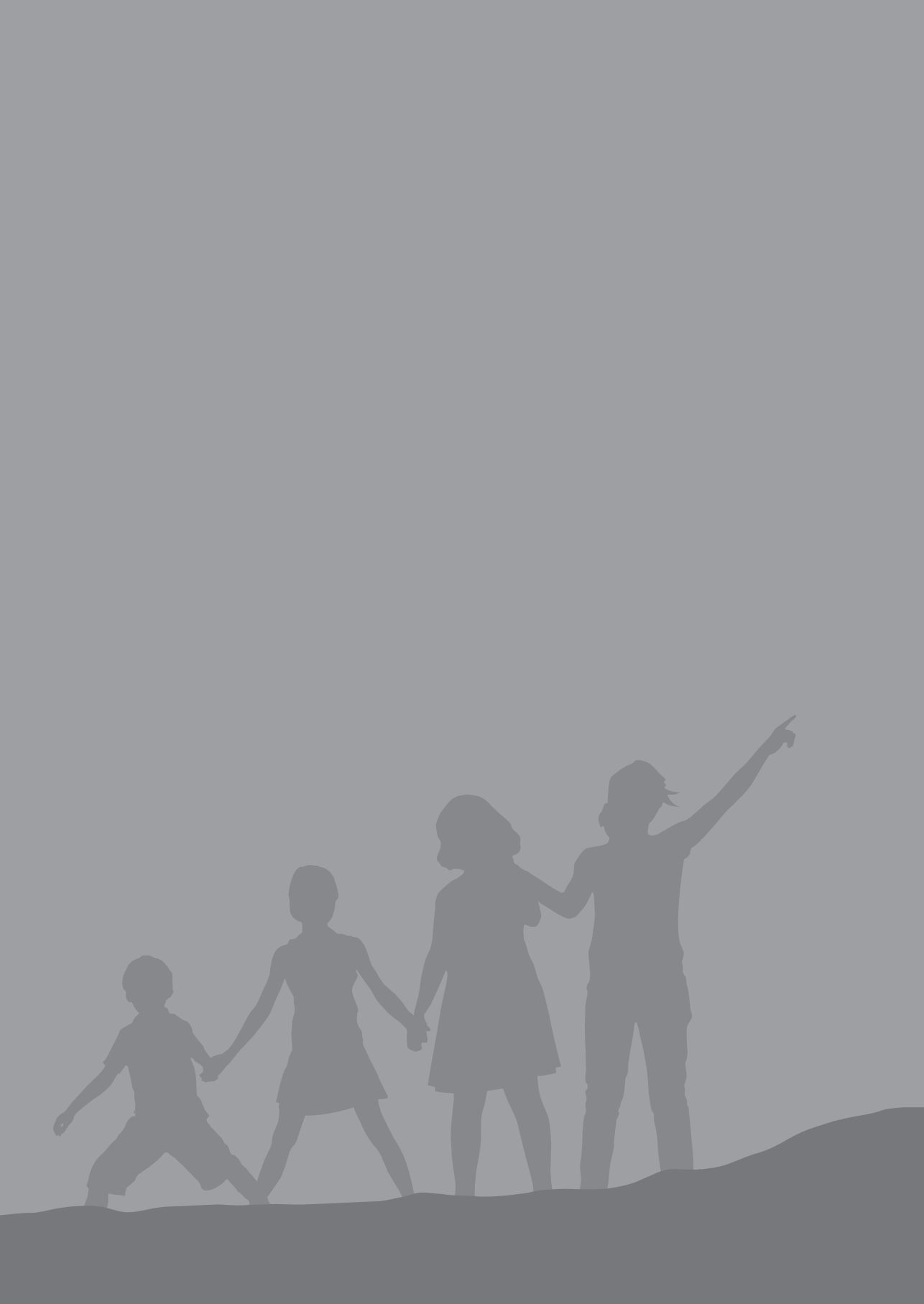
IV

About the author



CURRICULUM VITAE

Trudy Maria Arnoldina Wijnhoven was born in Venlo, the Netherlands on 22 July 1967. After completing secondary school (MAVO in 1983 and HAVO in 1985), she graduated in 1990 with a B.Sc. degree in Dietetics from the Hogeschool Nijmegen (Institution of higher professional education) in the Netherlands. In 1993, she earned a M.Sc. in Human Nutrition from Wageningen Agricultural University in the Netherlands. In 2006, she obtained a M.Sc. in Epidemiology: Principles and Practice (distance learning) from the London School of Hygiene and Tropical Medicine, University of London in the United Kingdom of Great Britain and Northern Ireland.

After graduation in Wageningen, she gained national work experience at Wageningen Agricultural University (Division of Human Nutrition) and the Royal Netherlands Society for Agricultural Sciences (KLV) in various research assistant positions. Then she joined the World Health Organization (WHO) in 1996 as an Associate Professional Officer and was stationed in Benin until 1998. From 1998 to 2005, she worked for the Department of Nutrition for Health and Development at WHO headquarters in Geneva, Switzerland. She was a valued member of the Coordinating Team for the WHO Multicentre Growth Reference Study (MGRS) Group, and coordinated the MGRS Motor Development Study in five countries (Ghana, India, Norway, Oman and the United States of America). In addition, she created a WHO database to compile child growth charts worldwide and analysed its contents, as well as updated and enhanced the WHO Global Database on Anaemia.

In August 2005, she started working for the WHO Regional Office for Europe in Copenhagen, Denmark as a core team member for the WHO European Ministerial Conference on Counteracting Obesity, convened in Istanbul, Turkey in November 2006. Then she became the focal point for nutrition and obesity surveillance data. In 2006, the Regional Office asked her to initiate and coordinate the WHO European Childhood Obesity Surveillance Initiative (COSI). As international COSI coordinator (until January 2015), she developed jointly with participating countries the COSI protocol and manuals for the training of examiners, data collection and data management. Furthermore, she reviewed the country datasets before merging and performing intercountry data analyses.

During the absence of a Regional Adviser on Nutrition from July 2008 to January 2010, she also managed the Nutrition and Food Security Programme. Furthermore from 2008 to 2011, she was the coordinator of the first joint WHO/European Commission project on monitoring progress in improving nutrition and physical activity and preventing obesity in the European Union (EU). In this position, she and her team developed the WHO European Database on Nutrition, Obesity and Physical Activity (NOPA database). Moreover, she was the Regional Office's focal point for European projects, such as EURO-PREVOB (Consortium for the prevention of obesity through effective nutrition and physical activity actions), the

EURRECA (EURopean micronutrient RECommendations Aligned) Network of Excellence, ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) and the EU Working Party on Information on Lifestyle and Specific Subpopulations.

She currently works in the Tobacco Control Programme at the WHO Regional Office for Europe. In this position, she gives technical support to countries implementing the Global Adult Tobacco Survey and the Global Youth Tobacco Survey.

LIST OF PUBLICATIONS

First author on peer-reviewed journal articles

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OVERVIEW OF COMPLETED TRAINING ACTIVITIES

Description	Organiser; Venue	Year
Discipline specific activities		
Courses		
WHO course "STEPwise approach to noncommunicable diseases risk factors Surveillance (STEPS) methodology"	WHO Headquarters; New-Delhi, India	2012
Master class "Multilevel Analysis"	Wageningen Graduate Schools (WGS) and Wageningen University, Division of Human Nutrition; Wageningen, the Netherlands	2011
WHO regional training of trainers course on child growth assessment	WHO Regional Office for Europe and WHO Country Office in Tajikistan; Tashkent, Tajikistan	2008
Conferences and meetings		
21st European Congress on Obesity (ECO) (oral presentation)	European Association for the Study of Obesity (EASO); Sofia, Bulgaria	2014
WHO Regional Office for Europe Nutrition Counterparts meeting (oral presentation)	WHO Regional Office for Europe; Tel-Aviv, Israel	2013
International Conference "Nutrition and Health" (oral presentation)	University of Latvia, Riga Stradiņš University and Latvian University of Agriculture; Riga, Latvia	2012
19th ECO (oral presentation)	EASO; Lyon, France	2012
International Conference on Childhood Obesity	Portuguese National Health Institute Doutor Ricardo Jorge; Lisbon, Portugal	2011
2nd World Congress of Public Health Nutrition (oral presentation)	World Public Health Nutrition Association; Porto, Portugal	2010
WHO Regional Office for Europe Nutrition Counterparts meeting (oral presentation)	WHO Regional Office for Europe; Geneva, Switzerland	2010
Technical Consultation to establish a regional nutrition surveillance system with focus on micronutrient malnutrition (oral presentation)	WHO Regional Office for the Eastern Mediterranean; Damascus, Syria	2009
WHO workshop on integration of physical activity data (oral presentation)	WHO Regional Office for Europe; Zurich, Switzerland	2009

Description	Organiser; Venue	Year
Meeting of the Organisation for Economic Co-operation and Development (OECD) Health Data National Correspondents (oral presentation)	OECD; Paris, France	2008
Central European Congress on Obesity "From Nutrition to Metabolic Syndrome" (oral presentation)	EASO; Karlovy Vary, Czech Republic	2008
WHO Regional Office for Europe Nutrition and Food Safety Counterparts meeting (oral presentation)	WHO Regional Office for Europe; Brussels, Belgium	2008
2nd European Summer School of Social Pediatrics "Nutrition and Early Child Development" (oral presentation)	European Society for Social Pediatrics and Child Health and Croatian Society for Preventive and Social Pediatrics; Dubrovnik, Croatia	2008
16th ECO (poster presentation)	EASO; Geneva, Switzerland	2008
2nd International Conference on Physical Activity and Public Health (poster presentation)	VU University; The Hague, the Netherlands	2008
International conference on nutritional surveillance in pre-adolescence in Italy (oral presentation)	Italian National Institute of Health; Orvieto, Italy	2007
2nd workshop on the new WHO child growth standards for the 12 Russian speaking Member States of the WHO European Region (oral presentation)	WHO Regional Office for Europe; Tashkent, Uzbekistan	2007
1st workshop on the new WHO child growth standards for the 41 non-Russian speaking Member States of the WHO European Region (oral presentation)	WHO Regional Office for Europe; Brindisi, Italy	2007
1st workshop for the exchange of experiences in physical activity and sports promotion in children and adolescents (oral presentation)	Swiss Federal Office of Sports, Swiss Federal Office of Public Health and HEPA Europe (European network for the promotion of health-enhancing physical activity); Magglingen, Switzerland	2006

Description	Organiser; Venue	Year
General courses		
Public speaking and presentation skills	WHO Regional Office for Europe; Copenhagen, Denmark	2013
Project and time management	WGS; Wageningen, the Netherlands	2011
Science, the press and the general public: communication and interaction	WGS; Wageningen, the Netherlands	2010
Netherlands Organisation for Scientific Research (NWO) Talent Class "Negotiating"	NWO; The Hague, the Netherlands	2010
Techniques for writing and presenting a scientific paper	WGS; Wageningen, the Netherlands	2010
Interpersonal communication for PhD students	WGS; Wageningen, the Netherlands	2008
PhD competence assessment	WGS; Wageningen, the Netherlands	2008
Optional courses and activities		
As part of the WHO European Childhood Obesity Surveillance Initiative: Preparation Research Protocol	WHO Regional Office for Europe; Copenhagen, Denmark, and National Institute for Public Health and the Environment (RIVM); Bilthoven, the Netherlands	2007
As part of the MSc. Programme "Epidemiology: Principles & Practice": Study unit EP304 "Advanced Statistical Methods in Epidemiology"	London School of Hygiene and Tropical Medicine; London, United Kingdom of Great Britain and Northern Ireland	Academic year 2004/2005
Study unit EP103 "Practical Epidemiology"		Academic year 2002/2003

COLOPHON

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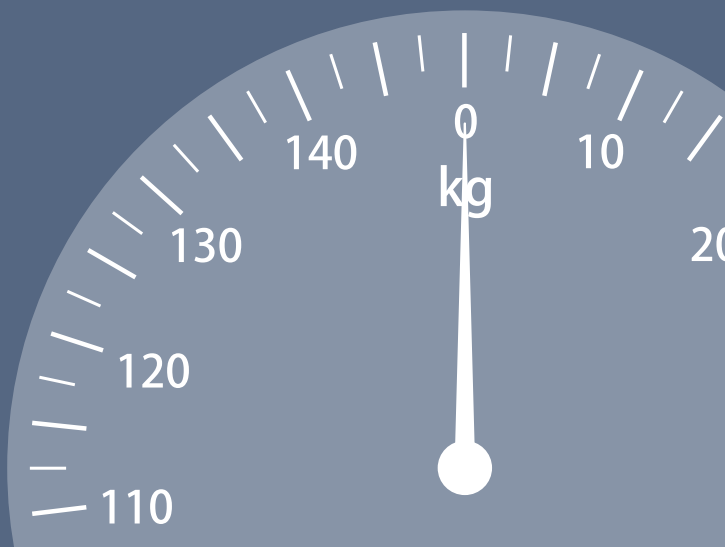
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