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Original Study

Cost-effectiveness of a Diet and Resistance Exercise Intervention in Community-Dwelling Older Adults: ProMuscle in Practice

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ABSTRACT

Objectives: Ageing is associated with a decline in functioning and a loss of independence, which will lead to increased health care costs in the future. The ProMuscle in Practice intervention was found to be effective in improving muscle strength, muscle mass, and functioning of older adults. The current study assesses the cost-effectiveness and perceived benefits of the intervention.

Design: Trial-based cost-effectiveness analysis complemented by interviews.

Setting and participants: A total of 168 community-dwelling older adults were included. Intervention participants started with a 12-week intensive support program, comprising resistance exercise guided by physiotherapists and consultations with a dietitian to increase protein intake. To maintain the adapted lifestyle pattern, they continued with a 12-week moderate support intervention. The control group received usual care.

Methods: Costs and outcomes were measured at baseline, after 12 and 24 weeks. Costs were assessed from a societal perspective. Health care use, out-of-pocket costs, and productivity losses were measured using questionnaires. Intervention costs were quantified according to bottom-up micro-costing. Outcomes included quality of life (EQ-5D-5L) and physical functioning (Short Physical Performance Battery [SPPB]). Bootstrap analyses were used to generate cost-effectiveness planes and acceptability curves. Interviews with participants and professionals were conducted after 24 weeks to measure perceived benefits.

Results: An Incremental Cost-Effectiveness Ratio of €2988 ($3385)/point increase in SPPB was found. The intervention has an 82.4% probability of being cost-effective at a willingness to pay (WTP) of €12.000 ($13.559)/point increase in SPPB. No change in quality of life was found according to EQ-5D-5L. Interviews, however, revealed a wide range of function-related perceived benefits.

Conclusions and Implications: At a WTP of €12.000 ($13.559)/point increase in SPPB, the intervention was found to have an 82.4% probability of being cost-effective. Because generic quality of life questionnaires seem unable to detect subtle changes in public health interventions, future studies are advised to include targeted and specific questionnaires.

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The proportion of the world's population aged 60 years and older is expected to increase from 12% to 22% between 2015 and 2050.[1] Ageing is often accompanied by conditions such as frailty and sarcopenia, leading to an increased risk of falls, hospitalization, and decreased quality of life.[2–4] Additionally, the ability to perform daily tasks tends to impair, and the need for help tends to increase, adding up to loss of independence.[5] Besides, ageing and its consequences are associated with increased health care costs.[3,6] In the United States, annual personal health care spending for adults aged 65 years and older has increased between 1992 and 2017 from $16.906 to $18.620 per person.[7] Older adults already accounted for 36% of total health care spending in 2016, and this number is expected to increase.[8] Specifically in the Netherlands, health care costs in older care are expected to increase by 153% (from €17 billion in 2015 to €43 billion in 2040).[9] These health and economic burdens ask for preventive strategies to counteract age-related impairments and to contribute to independence of older adults.

Previous research has shown that the combination of dietary protein supplementation and resistance exercise (RE) is an effective strategy to prevent sarcopenia and improve physical functioning.[10–14] Most of these effects were observed in a clinical, controlled setting and cannot directly be translated to the practice setting. Therefore, the efficacious, clinical program ProMuscle[15] was adapted and pilot-tested for the practice setting, resulting in the ProMuscle in Practice intervention (PiP). Adaptations included, for example, replacing the protein supplementation by an extensive nutrition program guided by a dietitian and the provision of protein-rich products.[16] PiP was implemented by physiotherapists and dietitians in the practice setting. After 12 and 24 weeks, community-dwelling older adults in the intervention group significantly improved muscle strength, muscle mass, and physical functioning compared to control participants.[17] Meaningful between-group differences were reported, that is, a change on Short Physical Performance Battery (SPPB) of 0.5 points (95% CI 0.1, 0.9) and a change on the chair rise test of 1.4 seconds (95% CI −2.3, −0.4) after 24 weeks.

The next step in development of PiP is to assess the cost-effectiveness of the intervention. To date, cost-effectiveness studies of similar interventions aiming to improve muscle strength, muscle mass, and physical functioning have not been conducted. However, economic evaluations of comparable interventions in older adults aiming to prevent falls are available, showing variable results regarding cost-effectiveness.[18–20] A recent systematic review included 12 exercise-based falls prevention programs in which different methods and willingness to pay thresholds were used. Ten studies used Cost Effectiveness Analysis and/or Cost Utility Analysis for economic evaluation and 2 studies reported medical costs as cost-utility. They reported 4 interventions to be cost-effective, 3 interventions as potentially cost-effective and 6 interventions to be not cost-effective on preventing falls.[20] Despite positive effects on falls prevention, reviews reported no or minimal effects on quality of life using generic questionnaires such as EQ-5D-5L or SF-36, indicating the importance to assess perceived benefits.[18,20]

Thus, findings on cost-effectiveness of falls prevention programs are inconsistent, and to date, no study has investigated the cost-effectiveness of a lifestyle intervention combining RE and an increased protein intake for older adults. Besides, limited changes in quality of life were found using generic questionnaires. Therefore, this study aims to assess the cost-effectiveness of the PiP intervention and gain insights into benefits regarding health-related quality of life.

Methods

Study Design

The current study was a trial-based cost-effectiveness analysis complemented with interviews. Economic evaluation was performed from the societal perspective with a time horizon of 24 weeks. The health care perspective was included as sensitivity analysis. The study design and sample size calculation of PiP are described in detail elsewhere.[17,21] In short, the randomized controlled trial (RCT) was implemented in a phased manner in 5 Dutch municipalities between 2016 and 2018 (first the intervention was implemented at location 1; a few months later, implementation began at location 2, and so on).

Study Population

Researchers recruited older adults via local media. Interested older adults received an extensive information brochure and were invited to an information meeting. After that, researchers screened older adults according to the inclusion criteria. Older adults' general practitioners checked the exclusion criteria, that is, renal insufficiency, allergy/sensitivity to milk proteins or being lactose intolerant, diagnosed chronic obstructive pulmonary disorder, cancer, or unregulated diabetes type 1 or 2 (see Supplementary Table 1 for complete list). Included participants ($n = 168$) were randomly assigned to the intervention or control group (stratified for sex and frailty), based on a randomization scheme generated by an independent researcher. The study protocol was approved by the Wageningen University Medical Ethics Committee, and all subjects gave written informed consent before the start of the study. PiP is registered at the Dutch Trial Register (identifier NTR6038).

Description of the Intervention

The intervention consisted of a 12-week intensive support program, followed by a 12-week moderate support program. The intensive support program included twice-weekly group-based progressive RE, primarily focused on the leg muscles, supervised by physiotherapists. Dietitians advised participants individually to increase their protein intake to 25 g per main meal, via an intake consultation, a contact moment in the first week, and an evaluation consultation in week 6. Besides, for the duration of 12 weeks, intervention participants received protein-rich foods, such as dairy foods, to incorporate in their diet.

After the first 12 weeks, intervention group participants were encouraged to continue with the optional moderate support program, to maintain their adapted lifestyle pattern. The program consisted of group-based RE 1-2 times a week at local fitness centers or physiotherapist practices and a nutrition course, comprising 5 group-based workshop meetings. An extensive description of the intervention is provided in Supplementary Material 1.

The control group participants received usual health care during the first 24 weeks and were asked to retain their habits regarding exercise and diet. After 24 weeks, the control group was offered to participate in the moderate support intervention. In the current study, we compared data from the first 24 weeks of the intervention and control group.

Data Collection and Outcomes

Measures

Participants visited the research center at baseline (T0) and after 12 (T1) and 24 weeks (T2). Measurements were performed by unblinded trained researchers and research assistants, following standardized protocols. Only the EQ-5D-5L questionnaire was additionally self-reported in weeks 6 and 18.

Physical functioning. The SPPB was used to measure physical functioning (score 0-12, 12 represents the best score). The test consists of 3 components, each with a maximum of 4 points: a standing balance, repeated chair-rise, and gait speed test.[22] Repeated chair-rise test in seconds was analyzed separately, because of its high correlation with lower body strength and functioning.[23] Fewer seconds on the chair-rise test represented a better performance.

Quality of life. The EQ-5D-5L questionnaire was used to measure health-related quality of life.[24] The questionnaire consists of 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has 5 answer categories: no problems (level 1), slight (2), moderate (3), severe (4), and extreme problems (5). The 5 dimensions and 5 levels lead to a health state score at each time point. The health state scores were then recalculated to a health utility (ie, a health score of 11111 indicates full health and has utility 1). The recalculation was performed using a "tariff" that was based on an EQ-5D-5L valuation study conducted in the Netherlands.[25] Health utilities were multiplied by the time spent in the health state, to estimate quality-adjusted life years (QALYs). Adding these scores established the total QALY for the 24-week period, with a maximum of 0.46 (24/52) for a person with the best possible health state at all measurement points.[25]

Health care use, out-of-pocket costs, and productivity losses. A health care use questionnaire was developed before start of the study, based on the iMTA Medical Cost Questionnaire.[26] It included cost categories that were deemed relevant for community-dwelling older adults (general practitioner, home care, informal care, dietitian, physiotherapist, occupational therapist, hospitalization, residential care, rehabilitation care, outpatient clinic, and medication use). Out-of-pocket costs included sports club memberships, purchase of sport equipment, and other out-of-pocket payments related to the intervention, such as braces or crutches. Productivity losses were measured using questions from the Productivity Cost Questionnaire.[27] Data on health care use, out-of-pocket costs, and productivity losses was collected in week 0, 12, and 24. In between measurements (week 1-12 and week 13-24) participants used a cost diary to keep track of their health care use, out-of-pocket costs, and productivity losses. Participants brought these diaries to the measurements to improve recall and accuracy in filling out the questionnaires. Trained researchers conducted measurements in a standardized manner, not differentiating between intervention and control participants.

Costs

Health care costs, out-of-pocket costs, and productivity losses. We used 2017 health care price levels, because the intervention was mainly delivered in that year. The *Dutch Guideline for Costing Analysis in Healthcare* was used to assess cost prices per unit for health care–related costs and productivity losses for unpaid work.[28,29] As this guideline included costs from 2014, those were adapted to 2017 levels applying Dutch consumer price index figures. Costs for medication use, sports club membership, sports equipment, and out-of-pocket payments were individualized. Detailed unit cost per category can be found in Supplementary Table 2.

Intervention costs. Bottom-up micro-costing was used to estimate intervention costs (which happens to be the gold standard).[28] Intervention costs were calculated per participant, and separately for the intensive and moderate support program. During the intensive program, health care professionals registered their working hours. These hours were multiplied by unit prices (hourly wage costs) for the specific professional. Intervention materials (eg, protein-rich products) were valued according to market prices. Fitness equipment was valued by the purchase price minus the selling price and divided by the number of participants in the intensive support intervention. Rent of rooms for RE training sessions were valued according to average renting prices for sports facilities in the 5 municipalities.

During the moderate support program, nutrition workshop supervisors registered their hours, which were multiplied by unit prices for dietitians. Costs for RE sessions at local sports centers were incorporated by including charges for sports club membership. Research-related study costs were excluded.

Interviews

After completion of the intervention, researchers conducted semistructured interviews with 4 intervention participants per municipality (n = 20 in total) and with health care professionals, comprising physiotherapists (n = 18) and exercise trainers (n = 9). Detailed information on methods regarding interviewing are described elsewhere.[30] Interview questions were used from the interview guide that was pretested during the pilot study.[16] In the current study, only data providing insights into perceived benefits were included. This information was obtained by asking interviewees whether they noticed effects or changes in participants.

Data Analyses

Quantitative analyses

Baseline characteristics were analyzed using independent samples *t* test or Mann-Whitney *U* test for continuous data, and Pearson chi-squared test or Fisher's exact test for categorical data. Data were analyzed according to the intention-to-treat principle (ITT). Multiple imputation models were used to impute missing cost and outcome data (10.2% on average). Data were analyzed with SPSS version 23 (IBM Corp., Armonk, NY).

Qualitative analyses

Qualitative data were analyzed using Atlas.ti version 8. Interviews were audiotaped and transcribed verbatim. One researcher (EJIvD) analyzed transcripts of interviews with health care professionals, and 1 research assistant (LB) analyzed transcripts of interviews with participants. Transcripts and analyses were checked by a third researcher (BD). Detailed information on coding is provided elsewhere.[30] Perceived benefits of the intervention were classified according to the 7 domains of the SarQol questionnaire.[31]

Economic analyses

The incremental cost-effectiveness ratio (ICER) was calculated by dividing the difference in costs by the difference in effects between the intervention and control group. The ICER was separately calculated for effects in SPPB, chair-rise test, and QALY (difference in effect between intervention and control group after 24 weeks) using bootstrap analyses with 5000 simulations. The ICERs were calculated from the societal perspective, including intervention costs, direct health care costs, patient and family costs, and other costs. The time horizon was 24 weeks. Therefore, no discounting was applied in this study.

Table 1
Baseline Characteristics of Participants of the ProMuscle in Practice Intervention

	Intervention (n = 82)	Control (n = 86)
Sex, female, n (%)	51 (62)	51 (59)
Age, y	74.7 ± 5.8	75.9 ± 6.5
Frailty status, n (%)		
Nonfrail	41 (50)	39 (45)
Prefrail	39 (48)	42 (49)
Frail	2 (2)	5 (6)
Bodyweight (kg)	76.3 ± 14.4	75.6 ± 13.6
Height (cm)	167.6 ± 9.0	169.2 ± 9.3
Educational level, n (%)*		
Low	2 (2)	4 (5)
Intermediate	54 (66)	42 (49)
High	26 (32)	40 (47)
Ethnicity: native Dutch, n (%)	79 (96)	81 (94)
Care use, n (%)	11 (13)	16 (19)
Alcohol use		
Drinker (≥1 d/wk), n (%)	52 (63)	59 (69)
No. of glasses/day	1.5 ± 0.8	1.9 ± 1.2
Smoking, n (%)		
Never smoked	32 (39)	30 (35)
Stopped >1 y ago	46 (56)	53 (62)
Current or stopped in last year	4 (5)	7 (3)
Morbidities, n (%)		
Diabetes	9 (11)	9 (11)
Arthrosis	38 (46)	42 (49)
Fractures	3 (4)	4 (5)
Other	69 (84)	67 (78)
SPPB total score (0-12)	10.1 ± 1.4	10.1 ± 2.0
Standing balance, points (0-4)	3.7 ± 0.6	3.6 ± 0.7
4-m gait speed, s	4.2 ± 0.9	4.2 ± 1.2
Repeated chair-rise, s	13.7 ± 3.4	13.1 ± 3.9
Health status score (0-1)	0.87 ± 0.10	0.86 ± 0.13

Data are presented as mean ± SD unless otherwise noted.
*Educational level, based on the Development of the Older Persons and Informal Caregivers Survey Minimal Dataset (TOPICS-MDS) questionnaire, low: primary school (less than 6 classes, 6 classes or full primary school), intermediate: secondary education or vocational school, high: higher vocational education or university.

Cost-effectiveness planes and cost-effectiveness acceptability curves were plotted. The latter indicate the probability of the intervention to be cost-effective compared to usual care, according to threshold values for willingness to pay (WTP). In the Netherlands, threshold values of €20.000 to €80.000 per QALY are used.[32] Currently, no threshold values are determined for SPPB or chair-rise test.

Sensitivity analyses

Sensitivity analyses comprised calculating ICERs from a health care perspective, including intervention costs and direct health care costs, and performing economic analyses for complete cases. Complete cases comprised participants with complete data for costs and included study outcomes.

Results

Table 1 presents baseline characteristics of the intervention and control group. No significant differences were found between the 2 groups. Baseline SPPB score was 10.1 ± 1.7, and baseline utility value for participants' health status was 0.86 ± 0.11.

Costs

Tables 2 and 3 show total costs during the 24-week study period in the intervention and control group. Average intervention costs were €1119 per participant, comprising €1014 for the intensive support intervention and €105 for the moderate support intervention. Direct health care costs were lower for the intervention compared to control group (€1336 and €1697, respectively). The total cost difference between the 2 groups was €890 for the societal perspective.

Effectiveness

Physical functioning: SPPB

After 24 weeks, an incremental effect in physical functioning of 0.3 SPPB points was found (95% CI −0.2, 0.8), as presented in Table 4. Effects in intervention and control group separately are presented in Supplementary Table 3. The incremental effect in complete cases was 0.6 SPPB points (95% CI 0.0, 1.2) (Supplementary Table 3).

Physical functioning: chair-rise test

The intervention group improved chair-rise test performance over time, whereas the control group decreased their performance (Supplementary Table 3). Mean difference between the 2 groups was

Table 2
Mean (SD) Costs for Intervention and Control Participants Over the Total 24-Week Study Period: Intervention Costs

	Unit Costs in € ($)*	Intervention (n = 82) Mean Total Costs € ± SD ($ ± SD)*	Control (n = 86) Mean Total Costs € ± SD ($ ± SD)*
Intensive support intervention			
Recruitment	13 p.p. (15)	13 ± 0 (15 ± 0)	0 ± 0
Materials	4 p.p. (4)	4 ± 0 (5 ± 0)	0 ± 0
Fitness equipment	82 p.p. (93)	82 ± 0 (93 ± 0)	0 ± 0
Protein-rich products	Individualized	264 ± 74 (299 ± 84)	0 ± 0
Rent of rooms	12 per hour (13)	55 ± 9 (62 ± 10)	0 ± 0
Physiotherapist hours (RE sessions)	34 per hour (38)	450 ± 88 (509 ± 100)	0 ± 0
Dietitian hours (consultations)	34 per hour (38)	145 ± 46 (164 ± 52)	0 ± 0
Subtotal		1014 ± 167 (1147 ± 189)	0 ± 0
Moderate support intervention			
RE sessions at local sports center	5 per session (5)	55 ± 20 (62 ± 23)	0 ± 0
Nutrition workshop	10 per session (11)	50 ± 9 (57 ± 10)	0 ± 0
Materials	1 p.p. (1)	1 ± 0 (1 ± 0)	0 ± 0
Subtotal		105 ± 27 (119 ± 31)	0 ± 0
Subtotal intervention costs		1119 ± 171 (1266 ± 194)	0 ± 0

p.p., per participant.
*Currency exchange rates accessed on July 6, 2020: €1 = US$1.12990.

Table 3
Mean (SD) Costs for Intervention and Control Participants Over the Total 24-Week Study Period

	Unit Costs € ($)*	Intervention (n = 82) Mean Total Costs € ± SD ($ ± SD)*	Care Use Intervention Group, n (%)	Control (n = 86) Mean Total Costs € ± SD ($ ± SD)*	Care Use Control Group, n (%)
Direct health care costs					
General practitioner	Supplementary Material 1	131 ± 199 (148 ± 225)	69 (84)	137 ± 132 (155 ± 149)	75 (87)
Home care	Supplementary Material 1	328 ± 649 (371 ± 734)	24 (29)	483 ± 1131 (547 ± 1280)	27 (31)
Consultations dietitian	34 per hour (38)	3 ± 7 (2 ± 8)	19 (23)	2 ± 9 (2 ± 10)	14 (16)
Consultations physiotherapist	34 per hour (38)	101 ± 184 (114 ± 208)	36 (44)	157 ± 222 (178 ± 251)	46 (54)
Consultations occupational therapist	34 per hour (38)	7 ± 16 (8 ± 18)	16 (20)	15 ± 53 (17 ± 60)	16 (19)
Hospital admission	489 per day (553)	259 ± 494 (293 ± 559)	24 (29)	258 ± 703 (292 ± 795)	20 (23)
Intensive care admission	2068 per day (2340)	40 ± 230 (45 ± 260)	11 (13)	6 ± 26 (7 ± 29)	4 (5)
Ambulance transportation	529 per ride (598)	32 ± 96 (36 ± 109)	17 (21)	37 ± 114 (42 ± 129)	17 (20)
Residential care admission	172 per day (195)	44 ± 102 (50 ± 115)	14 (17)	82 ± 401 (93 ± 454)	12 (14)
Residential care treatment	69 per half day (78)	1 ± 2 (1 ± 2)	10 (12)	1 ± 8 (1 ± 9)	5 (6)
Rehabilitation care admission	472 per day (534)	0 ± 0 (0 ± 0)	0 (0)	0 ± 0 (0 ± 0)	0 (0)
Rehabilitation care treatment	157 per hour (178)	3 ± 18 (3 ± 20)	11 (13)	1 ± 2 (1 ± 2)	4 (5)
Consultations outpatient clinic	93 per hour (106)	212 ± 242 (240 ± 274)	55 (67)	164 ± 197 (186 ± 223)	51 (59)
Medication use	Individualized	174 ± 153 (197 ± 173)	76 (93)	356 ± 1347 (403 ± 1524)	76 (88)
Subtotal		1336 ± 1466 (1510 ± 1656)		1697 ± 2656 (1917 ± 3001)	
Patient and family costs					
Sports club membership	Individualized	47 ± 56 (45 ± 63)	46 (56)	68 ± 88 (77 ± 100)	50 (58)
Sports equipment	Individualized	20 ± 32 (23 ± 36)	35 (43)	14 ± 43 (16 ± 49)	25 (29)
Out-of-pocket payments	Individualized	155 ± 244 (175 ± 276)	66 (81)	130 ± 251 (147 ± 284)	63 (73)
Informal care	14 per hour (16)	259 ± 649 (293 ± 734)	34 (42)	141 ± 332 (160 ± 376)	28 (33)
Subtotal		481 ± 815 (544 ± 921)		353 ± 520 (399 ± 588)	
Other costs					
Productivity loss unpaid work	14 per hour (16)	18 ± 58 (20 ± 66)	66 (81)	13 ± 35 (15 ± 40)	63 (73)
Subtotal		18 ± 58 (20 ± 66)		13 ± 35 (15 ± 40)	
Total costs					
Societal perspective		2953 ± 2055 (3341 ± 2325)		2063 ± 2858 (2334 ± 3233)	
Health care perspective		2455 ± 1479 (2774 ± 1671)		1697 ± 2656 (1917 ± 3001)	

*Currency exchange rates accessed on July 6, 2020: €1 = US$1.12990.

1.2 seconds (95% CI 0.4, 2.1) according to ITT (Table 4) and 1.5 seconds (95% CI 0.4, 2.6) in complete cases (Supplementary Table 3).

Quality-adjusted life years

According to ITT as well as complete case analyses, no significant changes between groups were found in QALY (Table 4, Supplementary Table 3).

Benefits of the program according to interviewees

Table 5 presents the perceived benefits of the intervention mentioned by the interviewees, classified according to the 7 domains of the SarQol questionnaire.[31] A broad variety of positive effects due to the intervention were mentioned, including an improvement in strength, vitality, mental state, balance, ability to walk, climb the stairs and cycle, and a reduction in fatigue during daily activities.

Cost-effectiveness

Physical functioning: SPPB

From the societal perspective, an ICER of €2988/point increase in SPPB was found according to ITT analyses (Table 4). Figure 1A presents the cost-effectiveness plane with 5000 bootstrap simulations. Most simulations were situated in the northeastern part of the cost-effectiveness plane, meaning an additional health effect was associated with additional costs. Figure 1B presents the cost-effectiveness acceptability curve, showing that the probabilities of the intervention being cost-effective are 82.4% and 85.4% at a WTP of respectively €12.000 and €20.000/point increase in SPPB.

Physical functioning: chair-rise test

An ICER of €728/s improvement in chair-rise test was found according to ITT analyses (Table 4). There was a 99.4% probability of the intervention being cost-effective at a WTP of €20.000/s improvement in chair-rise test.

Quality of life

An ICER of €7.337.501/QALY was found (Table 4), and the corresponding cost-effectiveness plane and cost-effectiveness acceptability curve were presented (Figure 1C and D, respectively). The ICER was found to be high because of the lack of difference in QALYs between the intervention and control group.

Table 4
Results of Cost-effectiveness Analyses Including SPPB, Chair-rise Test and QALY as Outcome Measure From the Societal Perspective

	n	Incremental Effect	Incremental Costs € ($)	ICER € ($)/ Outcome	Probability Cost-Effectiveness: WTP €20.000 ($22.654)/Outcome, %	Probability Cost-Effectiveness: WTP €80.000 ($90.603)/Outcome, %
SPPB	168	0.3	891 ($1007)	2988 ($3385)	85.4	88.9
Chair-rise test*	168	1.2	891 ($1007)	728 ($946)	99.4	99.4
QALY	168	0.0	891 ($1007)	7.337.501 ($8.290.642)	4.5	18.9

*Chair-rise test: analyses were performed with inverse minus/plus signs, to better present effects.

Sensitivity Analyses

Results of economic analyses from the health care perspective were in line with analyses from the societal perspective. Analyses of complete cases resulted in an ICER of €1945/point increase in SPPB (n = 101). The probabilities of the intervention being cost-effective at WTPs of €5.000 and €20.000/point increase in SPPB are, respectively, 92.9% and 99.1%. For the chair-rise test, results of complete case analyses were in line with ITT analyses.

Discussion

The current study showed that the PiP intervention has an 82.4% probability of being cost-effective at a WTP of €12.000/point increase in SPPB. This probability was 99.4% at a WTP of €20.000/s increase on the chair-rise test. No change in QALY on EQ-5D-5L was found, whereas interviews revealed a broad range of function- and quality of life–related perceived benefits.

Quality of Life

Comparable interventions targeted at fall prevention reported inconsistent results regarding cost-effectiveness, and often found no change in quality of life.[18–20] We as well found no change in QALY using EQ-5D-5L, for which the explanation is 2-fold. On the one hand, the mean health status of our study population at baseline was 0.86 ± 0.11, being slightly higher than the health status of a Dutch reference population aged 70 years and older (0.85 ± 0.15).[25] The relatively high baseline health status may represent a ceiling effect, limiting room for improvement. Often, public health interventions lead to limited changes in quality of life.[33] On the other hand, a generic questionnaire was used to measure quality of life. Although generic questionnaires are often used in economic evaluations and enable comparison of results between clinical studies, they seem to be insensitive to capture subtle changes in quality of life in older adults, as reported by cross-sectional studies,[34–36] a systematic review,[37] and meta-analyses.[38,39] So generic questionnaires are useful when investigating, for example, a diseased population in medical studies, but it seems that preventive interventions might need another approach.[40] For this reason, we additionally included performance measures. Conducting interviews led to a comprehensive overview of practical examples regarding perceived benefits. The qualitative results from the interviews were reflected by the quantitative results, showing improvements on muscle strength, lean body mass, and physical functioning.[17] Additionally, comparable interventions consisting of protein intake and resistance exercise show positive effects that are in line with our quantitative as well as qualitative results, including benefits on, for example, physical health, body composition, locomotion, and functionality.[13,14]

Specific questionnaires are needed to capture subtle changes in quality of life, and therefore quality of life questionnaires targeting particular conditions seem more suitable.[41-43] A broad range of specific instruments for musculoskeletal health is already available, including questionnaires for osteoporosis, arthritis, and sarcopenia.[41,42] The SarQol is a validated quality of life questionnaire specifically for sarcopenic older adults.[31,44-46] In our study, participants as well as professionals indicated a wide range of function-related perceived benefits due to the intervention (Table 5). These benefits corresponded with the domains of the target-specific SarQol questionnaire. Whereas measures such as EQ-5D-5L might not be able to detect the range of effects of a preventive intervention on the short term, adding targeted and specific quality of life instruments seems to be valuable.[46]

SPPB

Cost-effectiveness analyses resulted in an ICER of €2988/point increase in SPPB. The intervention has an 82.4% probability of being cost-effective at a WTP of €12.000/point increase in SPPB. An even higher probability (99.4%) of being cost-effective was found for the chair-rise test at a WTP of €20.000/sec improvement. No WTP thresholds are yet available for physical functioning outcomes. However, we can put value to these results, by clarifying the meaning of 1-point change in SPPB and by elaborating on care-related costs. Individuals with a lower SPPB score are predicted to have adverse outcomes such as decreased mobility, disability, hospitalization, nursing home admission, and even death.[22,47-51] More specifically, Volpato and colleagues showed that a 1-point increase in SPPB score at hospital discharge was associated with a 14% reduction of the risk of new hospitalizations and death combined over a 12-month period.[48] In line with this, Miller and colleagues showed that every 1-point increase in baseline SPPB score was related to a 5% decreased risk of hospitalization, a 12% decreased risk of subsequent mortality, and a 21% decreased risk of nursing home placement over a 36-month follow-up period.[50] Costs related to nursing home placement including daytime activities are €168 per day, adding up to €61.320 per year.[29] Besides, total health care costs for older adults in a nursing home including treatment are 10 times higher than for community-dwelling older adults in the Netherlands (€84.300 vs €7338 per person per year, respectively).[52-54] These findings show that an investment of €12.000 for a 1-point improvement in the SPPB score could lead to lower hospitalization, nursing home admission, and mortality and its associated costs in the long run.

Health Care Costs

A time period of 24 weeks is relatively short to capture changes in health care use, especially in preventive intervention programs.[40,55] Direct health care costs over the 24-week study period were higher in the control compared to the intervention group (€1697 ± 2656 vs €1336 ± 1466, respectively). Specifically, control participants had higher costs for physiotherapist consultations compared to intervention participants. Additionally, home care and medication use were higher in the control group, although those differences were mainly caused by a few participants having rather high costs compared with average. Future studies should include an extended follow-up period to measure possible changes in costs and effects on the long term. As health care use data were collected using questionnaires, both under- and overreporting may occur.[56,57] To enhance accuracy in collecting health care utilization data, we collected data every 3 months and participants used cost diaries to keep track of their health care use in between measurements.

Intervention Costs

Costs for the intensive support intervention were relatively high compared to the moderate support program (€1014 vs €105 per person, respectively). However, when implementing the intervention in the real-life setting, costs are lower. For the 12-week PiP implementation program, offered at several physiotherapist practices from 2019 onwards, participants were charged €210. The lower costs for the implementation program compared to the intensive intervention resulted from several factors. First of all, costs for purchasing fitness equipment and rent of rooms were eliminated, since the implementation program was conducted in the physiotherapist practice, that already provided access to equipment and rooms. Second, dietitian consultations were reimbursed by health insurance, as 3 hours of dietitian consultations per year are included in health insurance in the Netherlands.[58] Lastly, costs for protein-rich

Table 5

Overview of Perceived Benefits of the ProMuscle in Practice Intervention From Interviews With Participants (n = 20), Physiotherapists (n = 18), and Exercise Trainers (n = 9) Classified According to Domains of the SarQol Questionnaire

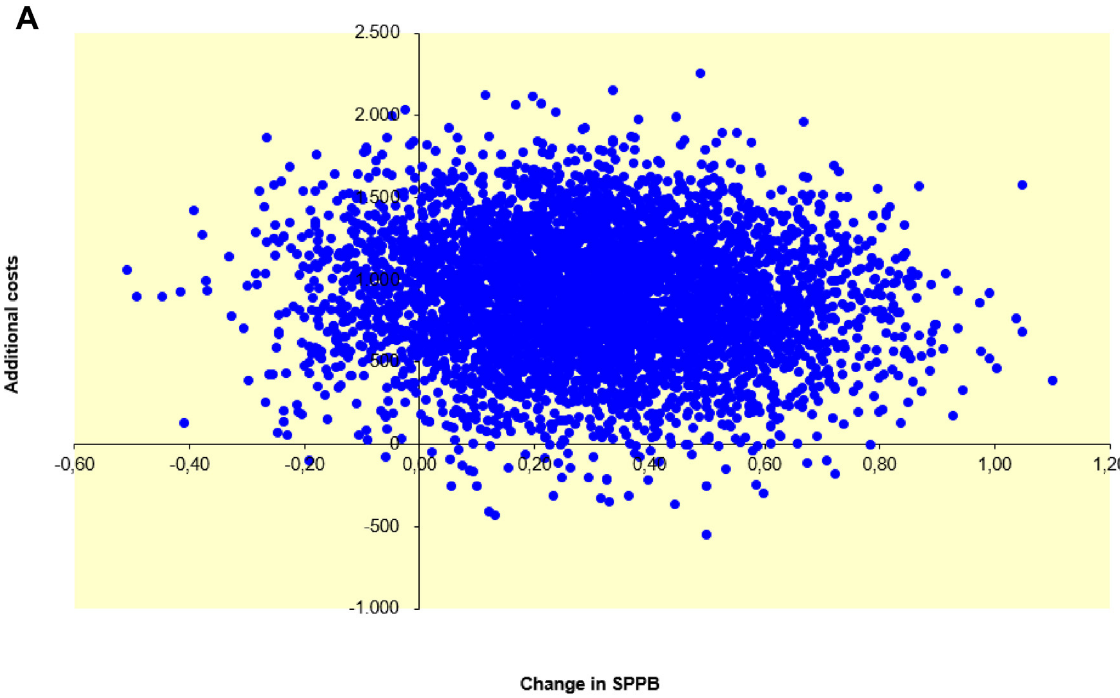
SarQol Domains	Aspects Mentioned by Participants During Interviews.[*] Due to the ProMuscle in Practice intervention, participants…	Aspects Mentioned by Physiotherapists During Interviews.[†] Physiotherapists mentioned that due to the ProMuscle in Practice intervention, participants…	Aspects Mentioned by Exercise Trainers During Interviews.[‡] Exercise trainers mentioned that due to the ProMuscle in Practice intervention, participants…
Physical and mental health	o Perceived an increased strength in their arms, legs or back (n = 4) o Felt really good/fit/vital, their energy level increased; physically as well as mentally (n = 6) o Noticed that working out is very important for the mind, and very relaxing (n = 1)	o Perceived an increased strength in their legs or arms (n = 5) o Felt fitter than before the program (n = 4) o Felt better, felt very well (n = 2)	o Perceived an increased strength (n = 2) o Felt the program is good for their mental state (n = 1) o Felt very well (n = 1)
Locomotion		o Increased their walking ability (n = 5)	o Moved much more freely than before the program (n = 1)
Body composition		o Had visible muscle growth, their skin was tighter (n = 3)	
Functionality	o Increased their ability to walk the stairs (is easier now) (n = 2) o Felt less stiffin the morning, and it was easier to get up and start the day (n = 2) o Noticed their muscles were activated (n = 1)	o Perceived an improved balance (n = 2) o Increased their ability to walk the stairs (n = 7) o Perceived they were standing more firmly and surely (n = 4)	o Perceived an improvement in balance (n = 2) o Perceived that the performance of the exercises is easier now (n = 2) o Increased their ability to walk the stairs (n = 2) o Increased their ability to get out of bed (n = 1)
Activities of daily living	o Were able to work in the garden for a longer period (n = 1) o Perceived an increased strength in their arms (it is now possible to open a jar) (n = 1)	o Reduced pain symptoms (n = 2) o Increased their ability to get out of the bathtub (n = 2) o Increased their ability to get dressed, tie their shoes (n = 3) o Increased their ability to get up from a chair (n = 2) o Were able to sustain activities for a longer period and suffer less from fatigue (n = 6)	o Mentioned that their shoulder injury has disappeared due to the exercises (n = 1) o Increased their ability to carry bags with groceries (n = 1) o Increased their ability to perform ADL (n = 1)
Leisure activities	o Increased their ability to cycle (is easier now) (n = 4) o Noticed their energy level to carry out activities increased (n = 1)	o Mentioned that cycling is easier, goes faster, is without pain now, can be sustained for a longer period and without the use of electrical support (n = 8) o Carried out more activities, eg, more walks in the neighbourhood (n = 2)	o Increased their ability to cycle (n = 1)
Fears		o Increased their self-assurance (n = 2)	

n, number of participants, physiotherapists, and exercise trainers who mentioned the aspect.

[*]In total, 20 participants were interviewed, but 3 did not participate in the moderate support program. 13 of 17 participants mentioned benefits of the intervention.

[†]In total, 18 physiotherapists were interviewed. In 1 interview, the topic of intervention effects was not discussed. The remaining 17 physiotherapists noticed benefits of the intervention.

[‡]In total, 9 exercise therapists were interviewed. One of the exercise trainers did not keep track of intervention effects. Seven of the exercise trainers noticed benefits of the intervention.



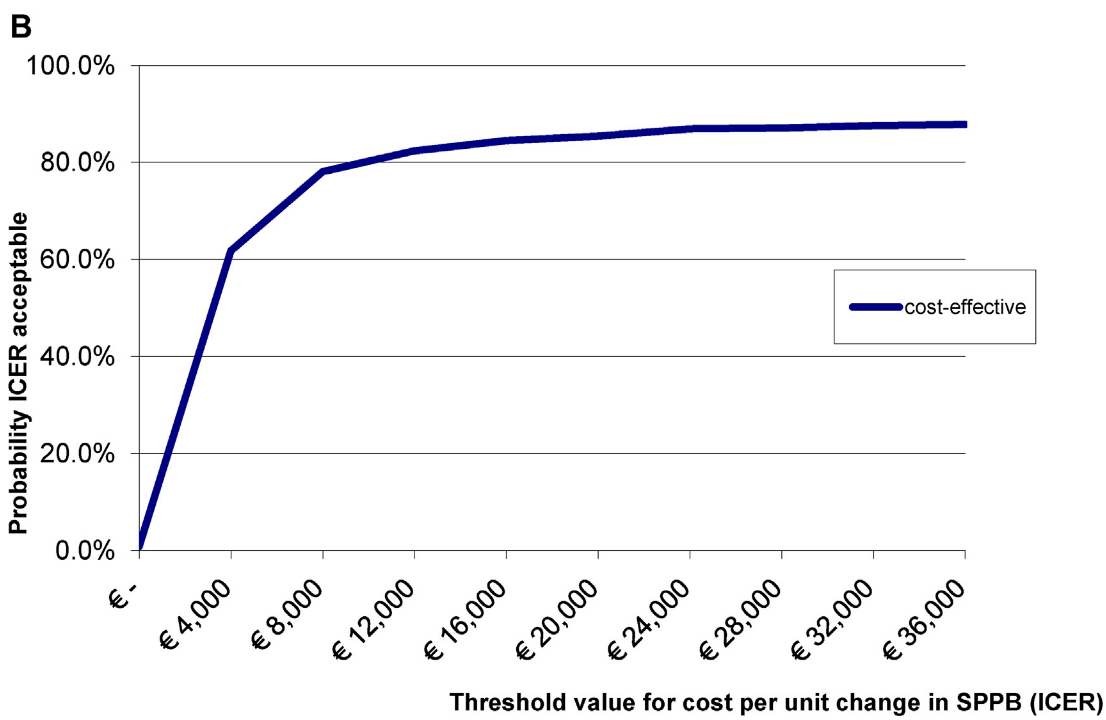


Fig. 1. Cost-effectiveness of the ProMuscle in Practice intervention compared to usual care, including SPPB (A, B) and QALY (C, D) as outcome measures. (A, C) Cost-effectiveness plane including 5000 bootstrap simulations. (B, D) Cost-effectiveness acceptability curve for change in, respectively, physical functioning or QALY (WTP/outcome).

products were lower during the implementation program. In the current analysis, we included costs for protein-rich products according to market prices. During the moderate support program, participants had to purchase their own protein-rich products, and 58% indicated no increased costs. The remaining 42% had average additional costs of €7 per week (€84 for 12 weeks). It is expected that costs of protein-rich products are comparable during the moderate support program and the implementation program. Overall, organizing the PiP implementation program results in lower costs compared to costs of the PiP intervention.

Conclusions and Implications

The PiP intervention resulted in a positive change in physical functioning and was found to have an 82.4% probability of being cost-effective at a WTP of €12.000/point increase in SPPB. The

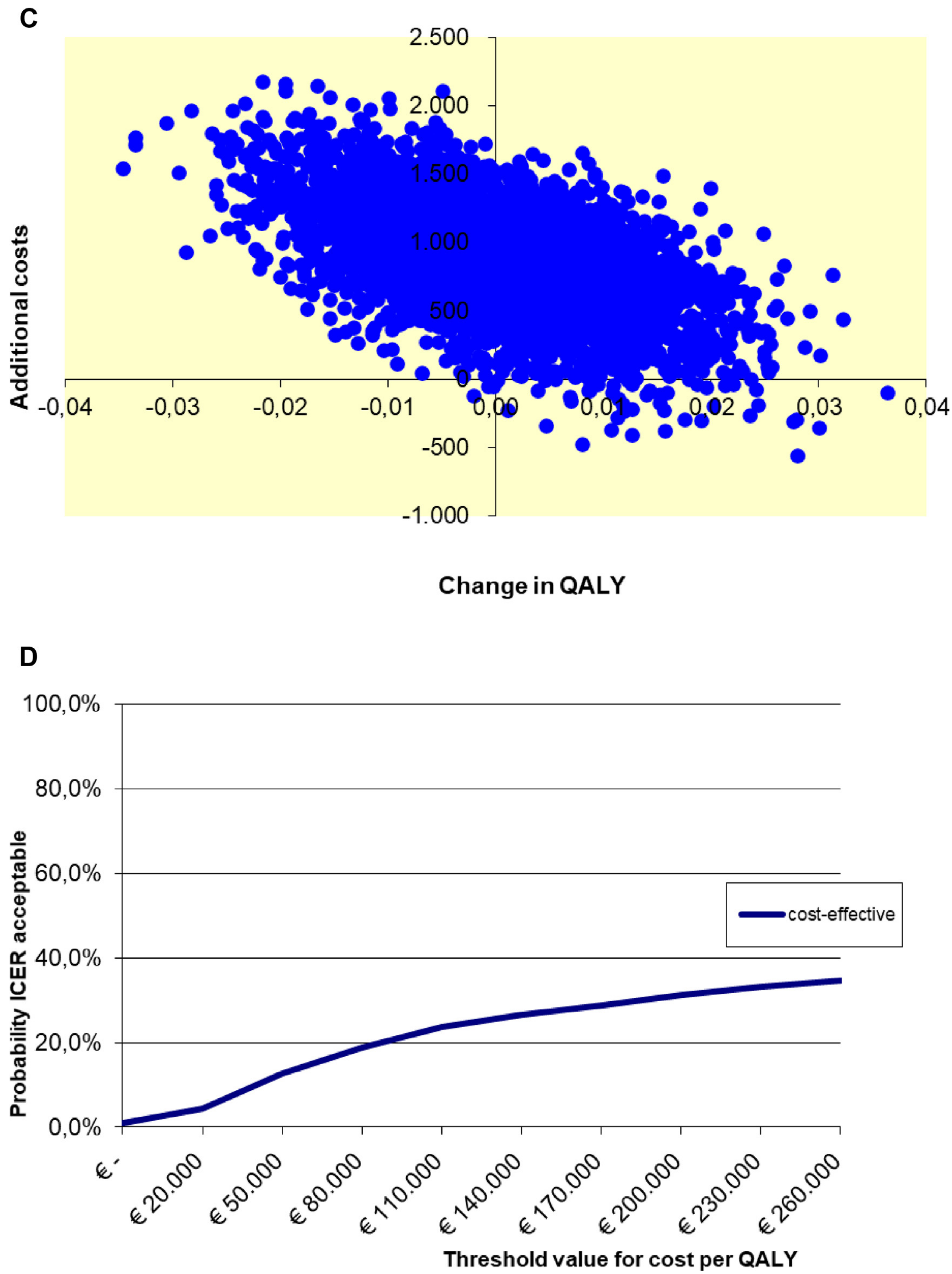


Fig. 1. Continue

EQ-5D-5L questionnaire did not measure any changes, whereas interviews revealed a range of function-related benefits. Because generic quality of life questionnaires seem less suitable to capture effects of preventive health interventions such as PiP, future studies are advised to include targeted and specific questionnaires.

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Supplementary Material 1. Extended Description of the Intervention

The intervention consisted of a 12-week intensive support program, followed by a 12-week moderate support program. The intensive support program included twice-weekly progressive resistance exercises (REs), primarily focused on the leg muscles. Each session had a duration of 1 hour, was group based (4-7 participants), and was supervised by physiotherapists according to PiP manuals. Training sessions consisted of a warmup, REs (leg press, leg extension, lateral pulldown, vertical row, and chest press), and a warm-down. The intensity of the exercises started with 3 to 4 sets of 15 repetitions (50% of 1-repetition maximum [1RM]) and extended to 4 sets of 8-12 repetitions (75%-80% of 1RM) in weeks 7-12. Additionally, a dietitian advised participants to increase their protein intake to 25 g per main meal, via individual consultations (at baseline, in the first week, and after 6 weeks). The dietitian provided information on the importance of a protein-rich diet and advised participants on how to achieve a protein intake of at least 25 g during breakfast, lunch, and dinner. Additionally, participants received protein-rich dairy products, cakes, or desserts, fitting with their preferences, to incorporate in their diet.

After the first 12 weeks, participants of the intervention group were encouraged to continue with the optional moderate support program, to maintain their adapted lifestyle pattern. Local fitness centers provided group-based RE training 1-2 times a week. Physiotherapists and other skilled trainers supervised the progressive RE sessions. Each training session had a duration of 1 hour and was mainly focused on leg muscles but also included additional balance or functional exercises. Strength exercises were described in a manual, but the type of exercises differed per location. Next to this, a health promoter and a dietitian conducted a nutrition workshop, comprising five 1.5-hour meetings. During each meeting, participants received information on dietary protein, they shared experiences, and prepared and tasted protein-rich dishes.

Supplementary Table 1
Inclusion and Exclusion Criteria of the ProMuscle in Practice Intervention

Inclusion criteria
Aged 65 y or older
Living independently in one of the selected municipalities (Apeldoorn, Epe, Ermelo/Putten, Harderwijk, Ede)
Mastery of the Dutch language
Score 1 or more points on the Fried frailty criteria[4]
Experience difficulties in daily activities and being inactive (ie, cannot participate in RE >30 minutes a day on more than 2 days a week)
Exclusion criteria
Allergy/sensitivity to milk proteins or being lactose intolerant
Diagnosed COPD or cancer
Diagnosed diabetes type 1 or 2 or hypertension (systolic blood pressure > 160 mmHg) that is unstable or not well regulated with medication
Severe heart failure
Renal insufficiency (eGFR < 30 mL/min)
Physical or cognitive impairment that hinder participation
Receiving terminal care
Not fully recovered from newly fitted artificial hip or knee prosthesis
Recent surgery (<3 mo)

COPD, chronic obstructive pulmonary disorder; eGFR, estimated glomerular filtration rate.

Supplementary Table 2
Detailed Description of Unit Costs Not Mentioned in Tables 2 and 3

Direct Health Care Costs	Unit Costs (€) ($)
General practitioner	
Visit to practice	33.9 per visit (38.3)
Phone contact for medical prescription	17.4 per contact (19.7)
Phone consultation	17.4 per consultation (19.7)
Home visit	51.3 per visit (58.0)
Visit to practice (outside working hours)	109.9 per visit (124.2)
Home care	
Domestic help	20.5 per hour (23.2)
Medication/support stockings assistance	51.3 per hour (58.0)
Personal care	51.3 per hour (58.0)
Nursing care	74.9 per hour (84.6)

Supplementary Table 3
Total Change Over 24 Weeks in SPPB, Chair-Rise Test, and QALY for the Total Study Population and for Complete Cases

	Intervention Group Mean ± SD	Control Group Mean ± SD	Mean Difference (95% CI)
Total study population	n = 82	n = 86	
SPPB (points)	0.2 ± 1.5	−0.1 ± 1.5	0.3 (−0.2, 0.8)
Chair-rise test (s)*	0.8 ± 2.8	−0.4 ± 2.8	1.2 (0.4, 2.1)
Total QALY over 24 wk	0.37 ± 0.06	0.37 ± 0.06	0.00 (−0.02, 0.02)
Complete cases	n = 51	n = 50	
SPPB (points)	0.4 ± 1.4	−0.2 ± 1.5	0.6 (0.0, 1.2)
Chair-rise test (s)	0.9 ± 2.6	−0.5 ± 3.0	1.5 (0.4, 2.6)
Total QALY over 24 wk	0.37 ± 0.06	0.37 ± 0.06	0.00 (−0.02, 0.02)

QALY, quality-adjusted life year; SPPB, Short Physical Performance Battery.
*Chair-rise test: analyses were performed with inverse minus/plus signs, to better present effects.