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Cost-effectiveness of a multicomponent training programme for older adults with decreased functional capacity: An economic evaluation

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ABSTRACT

Purpose: This study aimed to (I) examine the resources required to implement a multicomponent training (MCT) programme, (II) assess its impact on health care utilisation cost, and (III) evaluate its cost-effectiveness in older adults with decreased functional capacity.

Methods: A total of 123 older adults (mean age: 80.3 ± 5.9 years) were allocated into a control (CON, $n = 64$) or training group (TRAIN, $n = 59$). The TRAIN group performed a 6-month MCT programme, which included aerobic exercise, resistance training, flexibility and balance components, while the CON group continued with their usual care. Functional capacity, frailty and health-related quality of life (HRQoL) were assessed at three different timepoints using the Short Physical Performance Battery (SPPB), Frailty Phenotype of Fried and the EuroQol-5D (EQ-5D), respectively. Primary outcome measures included the costs of delivering the MCT, health care utilisation, quality-adjusted life-years (QALYs), and the incremental cost effectiveness ratio (ICER). Analyses were conducted from a health system perspective with a 6-month time horizon.

Results: While no significant changes were observed in the CON group, the TRAIN group showed improvements in SPPB (+3.38 ± 1.32), HRQoL (+0.07 ± 0.12), and frailty (−0.64 ± 1.06) (all $p < 0.05$). The average cost per

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TRAIN participant was €164. Health care utilisation cost was lower for TRAIN compared to CON (€3091 and €4135, respectively). The ICERs were €115/point increase in SPPB and €407/point reduction in frailty score. The cost per QALY gained by the TRAIN participant relative to the usual care cost was €6274. At a willingness-to-pay threshold of €49,000/QALY (Spanish Health System), the probability of the exercise intervention being cost-effective was 100 %.

Conclusions: The 6-month Exernet-Elder 3.0 training programme demonstrated an ICER of €115 per SPPB point gained, €407 per point of frailty reduction, and €6274 per QALY gained. The intervention was low-cost (€164 per participant) and produced clinically meaningful improvements in functional capacity, HRQoL, and frailty. These findings underscore the importance of integrating a structured, group-based exercise programmes into public health strategies to address the growing socioeconomic and health burden associated with ageing populations.

Trial registration: ClinicalTrial.gov identifier: NCT03831841

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1. Introduction

The proportion of people aged 65 and over is increasing globally. By around 2050, population trends suggest that the number of older adults will rise by up to 25 %, eventually outnumbering those under 25 years (World Health Organization European Region, 2023). Increased longevity may be perceived as a positive outcome; however, the proportion of individuals able to enjoy the last 15–20 years of life in good physical health remains limited and varies within and between countries (United Nations, 2020). If life expectancy continues to rise as predicted without a corresponding increase in quality of life (QoL), a greater number of people will spend extended periods living in poor health (MAK Tsz and Louro Caldeira, 2014).

Given this ageing process, health indicators such as functional capacity and health-related quality of life (HRQoL) are increasingly important (World Health Organization, 2018). Ageing is often accompanied by a decline in functional capacity and well-being, which may negatively affect life satisfaction (World Health Organization European Region, 2023; Fried et al., 2001). This decline may lead to frailty, which is a progressive age-related clinical condition characterised by reduced physiological reserves and increased vulnerability to external stressors (Rodríguez-Mañas et al., 2013). Frailty is associated with a decline in HRQoL and chronic disease, increasing the risk for developing fractures, falls, or cardiovascular diseases (CVD) among others (Chen et al., 2021; Fried et al., 2009).

Moreover, both ageing and frailty are associated with increased health care costs (Bruyère et al., 2019). For example, in the Netherlands, health care costs for older adults is expected to increase by 153 %, from €17 billion in 2015 to €43 billion in 2040 (Verschuuren et al., 2020). Additionally, demographic changes – including a shrinking working-age population and a growing proportion of older adults – pose challenges for pension systems, healthcare, and long-term care services (World Health Organization European Region, 2023). Therefore, preventive strategies are needed to maintain independence and reduce the burden on healthcare systems.

After explaining the role of ageing and frailty in health care cost, it is also important to analyse the impact of physical inactivity on the health care cost in this population. Inadequate physical activity is associated with a range of chronic diseases, such as coronary heart disease, stroke, type 2 diabetes (T2DM), breast cancer, colon cancer, and early death (Ding et al., 2016). Moreover, it is recognised as an independent risk factor for several prevalent and costly conditions -such as CVD, obesity, depression, and T2DM- (Allender et al., 2007), which constitute major public health challenges in primary care settings (Ding et al., 2016; Gusi et al., 2008). Conservatively estimated, physical inactivity cost international health-care systems approximately $53.8 billion in 2013, of which $31.2 billion was paid by the public sector, $12.9 billion by the private sector, and $9.7 billion by households (Ding et al., 2016). Furthermore, the progression from non-frailty to frailty can lead to a 101 % increase in total healthcare cost (Hajek et al., 2018), amounting to an annual cost of €2476 per frail older adult. In comparison, the average annual cost associated with the use of health resources is €1922 per older adult (García-Nogueras et al., 2017).

Given all of the above, there is a need for a major public health transition through the promotion of physical activity (PA) and frailty prevention programmes (Hoogendijk et al., 2019). Experts in the field have recommended encouraging exercise in older adults, as even moderate increases in PA have been shown to improve functional capacity and HRQoL (Esain et al., 2017), reduce the risk of frailty and disability (Guralnik et al., 1995; Bouaziz et al., 2016) and slow the decline in QoL (Groessl et al., 2019). Furthermore, evidence suggests that the benefits of exercise may be comparable to those of drug interventions in terms of their mortality benefits in the secondary prevention of coronary heart disease, rehabilitation after stroke, treatment of heart failure, and diabetes prevention. This supports its consideration as a viable alternative or complement to pharmacological therapies (Naci and Ioannidis, 2013).

According to the World Health Organisation and American College of Sports Medicine, PA is the major contributor to healthy ageing. These institutions recommend regular moderate-to-vigorous intensity aerobic activity and minimal sedentary behaviour to help prevent age-related illnesses such as sarcopenia, osteoporosis and CVD (Piercy et al., 2018). For additional health benefits, people can increase aerobic activities, incorporate muscle-strengthening and multicomponent training (MCT) (Bull et al., 2020; World Health Organization European Region, 2016), which included aerobic exercises, resistance training, flexibility and balance components, and is one of the most commonly used (Bouaziz et al., 2016; Izquierdo et al., 2021) and effective (Bouaziz et al., 2016; Cadore et al., 2013) interventions for older adults.

The effectiveness of exercise to improve functional capacity, HRQoL, frailty or chronic diseases in older adults is well established (World Health Organization European Region, 2023; Bouaziz et al., 2016; Groessl et al., 2019; Cadore et al., 2013; Subías-Perié et al., 2022a; Fernández-García et al., 2020; Subías-Perié et al., 2024); nevertheless, to our knowledge, no studies to date have analysed the cost-effectiveness of MCT in older adults with decreased functional capacity. Some economic evaluations have assessed the cost-effectiveness of exercise intervention in adults (Špacírová et al., 2019) or older adults (Subías-Perié et al., 2022a; Li et al., 2019; Groessl et al., 2016; Snowsill et al., 2022; Suikkanen et al., 2021), showing promising results. For instance, Fairhall et al. (Fairhall et al., 2015) reported that a 12-month exercise program involving lower-limb balance and strength training for frail, community-dwelling older adults was more cost-effective than usual care, particularly for the very frail, in whom it has a high probability of being cost saving, as well as effective. Similarly, Munro et al. (Munro et al., 2004) found that a MCT programme was more effective than many existing medical interventions in older adults and would be feasibly implemented by primary care commissioning agencies. Likewise, Gusi et al. (Gusi et al., 2008) showed that a 6-month walking programme was more cost-effective than usual care for elderly women in primary care. More recently, a systematic review by Chase et al. (Chase et al., 2025) found that exercise programs targeting adults with chronic conditions such as hypertension, T2DM, and fall risk showed consistent positive returns on investment and cost savings across multiple settings, further supporting the cost-effectiveness of exercise interventions.

These findings suggest that exercise interventions can be cost-effective in older populations; however, there remains a clear gap in the literature regarding the economic evaluation of MCT programmes specifically targeting individuals with decreased functional capacity. In this context, estimating the cost of health interventions is important for policy makers and governments, as it constitutes a key component in the assessment and improvement of the performance of their health systems. Moreover, to determine whether limited resources should be allocated to health interventions, it is necessary to consider whether the associated benefits outweigh the opportunity cost – namely, the benefits forgone if spending is redirected from other areas to remain within a fixed budget (Snowsill et al., 2022). Health economic evaluations compare the cost and benefits of health interventions, typically summarising the results using the incremental cost-effectiveness ratio (ICER), a standard measure of value for money. In Spain, there is currently no official cost per quality-adjusted life-year (QALY) gained, but some authors have recommended that interventions with an ICER €27,000 and 34,000/QALY should be accepted in 2022 (Subías-Perié et al., 2022a; Sacristán et al., 2002; Vallejo-Torres, 2025). In the United Kingdom (UK), health interventions are generally deemed cost-effective if the ICER falls below €23,425 to 35,141 (£20,000–30,000) per QALY gained (Li et al., 2019). In Canada and the United State of America (USA), a commonly accepted willingness to pay (WTP) threshold is approximately CAD $68,623 or US $50,000 per QALY gained, which corresponds to around €46,179 based on recent exchange rates (Rubio-Terrés et al., 2004).

Thus, the main objectives of this study were: (1) to describe the resources required to perform the MCT exercise programme and the health system cost utilised by the participants in the project; and (2) to analyse the cost-effectiveness and cost-utility of a 6-month MCT programme in older adults with decreased functional capacity. These results could inform and assist policy makers, governments or others involved in healthcare decisions about the degree to which alternative interventions improve health, given their cost. We hypothesised that our 6-month MCT programme would be a cost-effective health tool for older adults with decreased functional capacity.

2. Methodology

2.1. Study design

In this health economic evaluation, the data for the current cost-effectiveness analysis (CEA) come from a quasi-experimental study previously carried out between 2018 and 2020 within the framework of the EXERNET-Elder 3.0 project (Fernández-García et al., 2020). The evaluation was conducted from a healthcare system perspective as significant drivers of cost are within the healthcare sector. As QALY is a metric that can be used across all diseases allowing comparisons, a cost-utility analysis was undertaken as the primary analysis (Neumann et al., 2017). Secondarily, we delivered a CEA including the incremental cost per frailty and physical disability averted or functional capacity gained. In addition, a checklist was reported in line with the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2022 (Husereau et al., 2022). This study was registered in the electronic repository clinicaltrials.gov (reference number: NCT03831841).

2.2. Study population

Researchers recruited older adults from 3 nursing homes and 4 healthcare centres from Zaragoza, Spain. They then screened participants according to the following criteria: (a) being older than 65 years; (b) having a decreased functional capacity (4–9 pts) according to the cut-off pts. of the Short Physical Performance Battery (SPPB) (Treacy and Hassett, 2018; Guralnik et al., 2000); and (c) not suffering from dementia and/or cancer. Although participants with dementia or cancer were excluded, they were not necessarily free of other chronic conditions. As expected in this population, common comorbidities such as metabolic syndrome (37.3 %), hypertension (13.6 %), hypertriglyceridemia (33 %) and T2DM (30 %) were present among participants (Subías-Perié et al., 2022b). In total, 169 older adults were initially derived from the centres mentioned above, but only 123 participants met the inclusion criteria and were enrolled in the project. The sample was assigned by convenience into the training (TRAIN) or control (CON) groups to enhance training attendance according to participant's preferences and availability. The TRAIN group performed a supervised 6-month MCT followed by a 4-month detraining period in which training was interrupted, and they continued with their routine activities, whereas the CON group followed their usual healthcare and lifestyle regime throughout the course of the project but underwent identical testing to the TRAIN group at baseline and follow-ups.

All potential participants received oral and written information about the aims, possible benefits and risks derived from participation in this study. Afterwards, all participants gave their written informed consent before the start of the study. The project was performed in accordance with the Ethical Guidelines of the Declaration of Helsinki of 1961, revised in Fortaleza, Brazil (World Medical Association, 2013) and the current legislation for human clinical research in Spain (Law 14/2007). The study protocol was approved by the Hospital Universitario Fundación de Alcorcón Ethics Committee (16/50).

2.3. Description of the intervention

The MCT programme was implemented between January and June 2019 and lasted 6 months. Four qualified and trained instructors supervised all training sessions. The maximum target group size was 16 participants. All of them always trained in the same group of participants and, to reduce interprofessional variability during the exercise programme, the instructors were trained to standardise the training protocol. One of them, who had a degree in sports and PA sciences, acted as coordinator of the instructors.

The 6-month MCT programme consisted of three supervised sessions per week (a total of 72 sessions), each lasting 60 min. The first (Monday) and third (Friday) weekly sessions, termed “Strength and Functional sessions”, focused on enhancing muscular strength, power and static balance through exercises that simulated activities of daily living. Participants performed many types of exercises involving large muscle groups through one or more joint actions (e.g., push on chest and pec fly, shoulder press, flexion, triceps push down, bicep curl, quadriceps extension, leg curl, hip abduction, adduction, flexion and extension). In addition, strength sessions included static balance exercises, which consisted of maintaining different positions and, in the most advanced phases, exercises that simulate daily living activities. The strength training protocol was based on the three principles of the consensus statement by Fragala et al. (Fragala et al., 2019): individualization (exercises were adapted to each participant's ability level), periodization (establishing specific goals with a systematic variation in the training stimulus), and progression (increasing training demands through modifying variables such as intensity, recovery times or volume). Each session included 6 to 8 types of exercises, performed in one to three sets of 8 to 15 repetitions).

The second weekly session (Wednesday), referred to as the “Endurance sessions”, included aerobic activities such as walking, steps exercises, and use of a stationary cycle (for legs, arms, or both). In addition, participants performed dynamic balance and coordination tasks – such as directional changes, square stepping, obstacle negotiation, and other activities that challenged the centre of gravity. Motor skill activities involving ball and balloons were also included. The equipment used for ES were psychomotricity material, agility ladders, static cycles, steps, dumbbells, weighted anklets, balls and balloons.

All sessions were spaced 48 h to prevent excessive muscle fatigue. Each session followed a structured format comprising approximately 10 min of warm-up, 35–40 min of main exercises, and 10–15 min of cool down, involving flexibility, breathing control exercises and a cognitive task (e.g. memory, calculation, orientation, language, reasoning, and executive functions exercises). Further details about the MCT programme are given in the study protocol (Fernández-García et al., 2020).

Furthermore, participants of both groups received 3 talks related to healthy habits to engage CON participants throughout the study, reducing the possible drop-off caused by multiple evaluation periods. The topics of these talks were the following: "*Functional capacity and frailty*", "*Nutritional recommendations for older people*", and "*Physical exercise to improve health in older people*". These talks were delivered by a certified sports scientist, nurse and nutritionist respectively.

2.4. Outcome measures

Participants were assessed at three different time points throughout the course of the project: at baseline, before the training period began (T0: baseline assessment); immediately after the 6-month exercise intervention to evaluate the instant effects after MCT programme (T1: post-training assessment); and after a 4-month detraining period to assess the lasting effects following the MCT programme (T2: post-detraining assessment). Trained researchers and research assistants – who were not blinded to group allocation due to logistical and staffing limitations – performed the measurements using structured questionnaire, physical analysis, and standardised protocols. To minimise potential bias, all assessments were conducted following strict procedures and validated tools.

2.4.1. Health-related quality of life

The Euroqol-5D (EQ-5D) questionnaire (Badia et al., 1999) is a generic instrument used to measure HRQoL. The first element is a descriptive system that includes 5 dimensions: (1) mobility; (2) self-care; (3) activities of daily living, (4) pain and discomfort; and (5) anxiety or depression The scale of dimensions is from 1 to 3 (no problems, some problems, or extreme problems). Subsequently, it also includes a visual analogue scale of health-reported rating ranging from 0 to 100, with 0 being the worst imaginable state of health and 100 being the best (Group E, 1990). Using a combination of these dimensions, a total of 243 possible health states exists. Each health state has been previously defined using the time trade-off method of utility analysis based on the response of a sample of the Spanish population (Badia et al., 1999). Depending on the total score of this questionnaire, the result is scaled from 0 (reflects death) to 1 (reflects perfect health). Health utilities were multiplied by the time spent in the health state, to estimate QALYs. This measure combines the duration of life lived with the QoL experienced.

2.4.2. Functional capacity

The SPPB measures normal gait speed, chair rises, and standing balance, each from 0 (unable to complete) to 4 (best performance), with a total battery score of 12 pts. (Treacy and Hassett, 2018) and three main functional stages: invalid (0–3 pts), decreased functional capacity (4–9 pts), and maintained functional capacity (10–12 pts) (Guralnik et al., 2000).

2.4.3. Frailty status

The Frailty Phenotype of Fried was used to evaluate the frailty status of participants. This test includes 5 items: unintentional weight loss (defined as a loss of ≥4.5 kg or ≥ 5 % of body mass in the last year), self-reported exhaustion (felling especially tired or having poor endurance and energy during the last week), weakness (handgrip strength in lowest 20 % quintile adjusted for sex and body mass index), slow usual gait speed (walking speed in the lowest quintile, adjusted for sex and height, typically assessed with a 4.5-m walk test and a cutoff of <0.8 m/s), and low PA (kilocalories expended in PA in the lowest quintile during the past week, calculated based on the modified questionnaire Minnesota Leisure Time Activity Questionnaire, and defined as <2 h of walking per week based on self-reported activity levels). Depending on the result, there are three main frailty status: robust (0 items), pre-frail (1 or 2 items) and frail (3 or more items) (Fried et al., 2001; Bieniek et al., 2016).

2.4.4. Body composition and anthropometric measurements

A body composition analyser based on Bio-Electrical Impedance Analysis with 200 kg maximum capacity and 50 g error margin (TANITA BC-418MA, Tanita Corp., Tokyo, Japan) was used to measure the body mass (kg), body fat (%), and fat free mass (kg). Participants removed their shoes and heavy clothes before weighing. All measurements were performed at same hour, with empty bladder and same conditions for all participants and evaluations.

Anthropometric measurements were registered according to the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Marfell-Jones et al., 2012) by two researchers accredited as ISAK level 1 anthropometrics. A portable stadiometer with 2.10 m maximum capacity and 1 mm error margin (Seca, Hamburg, Germany) was used to measure height. Waist and hip circumferences were taken using a flexible non-elastic measuring tape Rosscraft Anthrotape (Rosscraft Innovations Inc., Vancouver, BC, Canada).

2.4.5. Costs

The costs of delivering the MCT programme and health care utilisation were recorded for this economic evaluation. All unit costs are expressed in 2019 Euros (€).

- *Health care utilisation*

The costing of the health care utilisation had a fixed unit cost assigned and was calculated according to the 2019 updated official prices by the Regional Ministry of Health to the Health Area of Aragón. We used 2019 health care price levels, because the intervention was mainly performed in that year. The health services were recorded, including medication use; physician (primary care), nurse (primary care), specialist physician (secondary care), physiotherapist, social worker, occupational therapist and dietitian services; urgent care or emergency rooms visits; hospital days; diagnostic imaging test use; and blood and urine test use; exercise stress test; and biopsies. Medication use was obtained through a structured questionnaire and checked with the electronic prescription that participants brought to the assessments. The other health care services were recorded through the electronic Regional National Health System of Aragón. Health care resources were collected from the 6 months before and 6 months after the exercise programme.

- *Intervention costs*

The cost of implementing the exercise programme was estimated from records of exercise instructor time, exercise equipment and sports facilities. During the exercise programme, specialized instructors recorded their working hours. These hours were multiplied by unit prices (hourly wage costs) for the sport science professional. Moreover, the time needed to prescribe and coordinate the exercise programme by a graduate in sport science was recorded. These unit prices were obtained from the Official State Gazette of the IV State Collective Bargaining Agreement for sports facilities and gymnasiums published in 2019, by the Ministry of Labour, Migrations and Social security (Ministerio de Trabajo M y SS, 2019). Exercise equipment was valued by the purchase price divided by the number of participants in the TRAIN group. Sports facilities to develop the MCT programme were valued according to renting prices for public sports centres in the city of Zaragoza in 2019 (Vicerrectorado de Cultura y Proyección Social, 2024). All research-related study costs were excluded.

2.5. Cost-effectiveness analysis

The economic analysis was approached from the health and community care funder perspective, which allows employers, health care and community organisations to measure the approximate cost of offering this exercise programme. Furthermore, the economic evaluation was performed according to intention-to-treat analysis, including all participants who were assessed, regardless of whether they completed or dropped out of the trial.

The total costs of developing the exercise programme for the TRAIN group and the costs of health care utilisation in both groups were included in calculating the ICER. So, the differences in costs and effectiveness between the TRAIN and CON groups were used to calculate the ICER. The incremental cost per participant was then divided by the incremental effectiveness to get the ICER, given by the formula = (Ct-Cc)/(Et-Ec), where Ct is the exercise programme and health services for the TRAIN group; Cc is the health services for the CON group or usual care; Et and Ec are the health effects obtained by the TRAIN and CON groups, respectively. The ICER is the ratio of the added costs of an intervention to the added benefits, which are typically measured using functional capacity (identified as an improvement on the baseline SPPB score), frailty (identified as an improvement on the baseline Frailty Phenotype of Fried score), or QALYs gained in the TRAIN group compared with the CON group.

Sensitivity analysis in economic assessments of health interventions is important, because this analysis allows better decisions to be made when it comes to choosing a specific health intervention. These decisions are made with the available data at the specific time but, these data could be affected by both random and non-random (or bias) errors, which produce reliability and validity problems, respectively. Moreover, as the true values of variables are unclear, the obtained results in the statistical analysis should check the degree of stability or robustness. Furthermore, it is important to examine if the results obtained in a specific sample can be extrapolated to other patients or fields (Rubio-Terrés et al., 2004).

The proposed trial-based cost-effectiveness analysis considers the possibility of dealing with missing data on cost or effectiveness variables by working with multiple imputation techniques for subjects with missing data, specifically the number of replicates is M = 4. We also consider an analysis that allows modelling correlations between costs and health outcomes, using seemingly unrelated regression models (SUR) combined with the bootstrap as a non-parametric inference method, which also adequately handles costs and/or biased effects. In addition, this analysis procedure allows for an integrated handling of possible imbalances in the design of the groups. The calculation of the statistics to obtain an estimate of the ICER for each health outcome is based on the R tutorial developed by Ben AJ et al. (Ben et al., 2023).

A non-parametric bootstrap procedure is used to estimate and graphically illustrate the statistical uncertainty surrounding ICERs by plotting bootstrapped cost-effect pairs of increments on the cost-effective plane based on 5000 replications. The probability of an exercise programme in older adults being cost-effective compared with usual care or CON is presented as a function of a varying WTP in cost-effectiveness acceptability curves, because the elemental WTP is unknown. To report uncertainty due to sampling variation, non-parametric bootstrap techniques were used to calculate the 95 % confidence intervals.

The economic evaluation was based on a cost-utility analysis calculating the incremental QALYs expressed in days fitted to the survival period of each patient estimated by the time-trade-off social preference using the Spanish reference values of EQ-5D (Badia et al., 1999). This questionnaire was collected at T0, T1 and T2 assessments. The analytic time horizon was 6 months. Therefore, no discounting was applied in this study.

2.6. Data analysis

The Statistical Package for the Social Sciences v. 25.0 for Windows (IBM SPSS, Inc., Chicago, IL, USA) and R project for Statistical Software v. 4.3.3 were used for all statistical analyses (Ben et al., 2023). Continuous variables are presented as mean and standard deviation. The statistical significance level was set at $p < 0.05$ in all tests. The Shapiro–Wilk test was used to analyse the distribution of the variables. All variables showed a normal distribution.

The main outcome was EQ-5D utility. The number of participants to be included in the study was calculated based on the change in the QoL with the Spanish EQ-5D data set for a hypothetical study comparing two groups, accepting a beta risk of 0.2 (power of 80 %) and an alpha risk of 0.05 (5 % alpha level) in a bilateral contrast, a total sample size of 94 (47 per group) is needed to detect a difference equal or greater than 0.1 units. The common standard deviation is assumed to be 0.17 (Gusi et al., 2008). But the sample was incremented by 20 % to contemplate possible losses during follow-up. Thus, the required study sample was 114 participants (57 per group). The final sample included in this research was of 123 participants.

An independent *t*-test was used to examine differences between groups in descriptive characteristics and in each assessment. Moreover, in health variables assessed though scales, the non-parametric Mann-Whitney *U* test was used to analyse differences between groups in frailty status and HRQoL.

Although only T0 and T1 effects of MCT programme are reported in this research, data from all three assessments timepoints (T0, T1, and T2) were considered in the cost-effectiveness analysis. The T2 data, were used within the economic model, but effectiveness results at this assessment were not included in this manuscript to maintain focus and avoid redundancy, as they have been published elsewhere (Fernández-García et al., 2022; Moradell et al., 2023).

3. Results

Descriptive characteristics at baseline of the included participants are shown in Table 1. Body mass, height and fat-free mass showed significant differences between the TRAIN and CON groups at T0 (Cohen's d ranged from 0.41 to 0.53; $p < 0.05$). Regarding attendance, the average rate collected by the TRAIN participants was 83.2 ± 10.6 %.

3.1. Effectiveness

The results of the main outcomes are presented in Table 2, in which 123 participants were included in the analysis. There were no differences between groups at T0 in SPPB, frailty and QoL, but after the 6-month MCT programme there were significant differences between groups in these variables at T1. Moreover, after a 6-month MCT programme, the TRAIN group obtained an incremental effect in SPPB (3.38 ± 1.32) and HRQoL (0.07 ± 0.12), and a reduction of frailty (−0.64 ± 1.06). However, the CON group did not show changes for this period.

3.2. Intervention costs and health care utilisation

Tables 3 and 4 show total costs of delivering the exercise programme and the health care utilisation (Fig. 1) during the whole project in the TRAIN and CON groups. The average cost of exercise programme was €164 per participant. Based on actual attendance (83.2 %), the cost per attended exercise session per participant was approximately €2.74. Health care utilisation cost was lower for the TRAIN group compared to the CON group (€3091 and €4135, respectively).

Table 5 shows the total cost of delivering the MCT programme and direct health service per participant. The direct health cost increased in the TRAIN group from T0 to T1; however, the CON group obtained a similar cost. Nevertheless, the total cost per participant was higher in the CON group, both before and after the exercise programme.

Table 1
Socio-demographic, anthropometric, body composition, and functional capacity characteristics of the subjects at baseline.

Characteristics	TRAIN (n = 59)	CON (n = 64)	*p*-Value	Effect Size d or r
Socio-demographic				
Age (years)	80.6 ± 6.2	79.9 ± 5.7	0.507	0.12
Sex, (Female n, [%])	39 (66.1)	52 (81.2)	0.056	
Anthropometrics and body composition				
Body mass (kg)	75.2 ± 14.6	69.3 ± 13.4	0.024#	1.13
Height (cm)	159.3 ± 8.7	155.1 ± 7.2	0.011#	0.53
BMI (kg/m^2)	29.9 ± 5.1	29.0 ± 5.7	0.380	0,16
Body fat (%)	37.2 ± 6.5	37.5 ± 7.4	0.809	0.04
FFM (kg)	46.8 ± 9.8	42.7 ± 7.1	0.016#	0.48
Hip circumference (cm)	104.3 ± 8.4	103.8 ± 11.1	0.834	0.05
Waist circumference (cm)	94.9 ± 12.1	92.4 ± 13.5	0.335	0.19
Functional capacity				
SPPB score (pts)	7.5 ± 1.8	7.8 ± 1.7	0.298	0.17
Frailty score (pts)[a]	1.5 ± 1.3	1.5 ± 1.2	0.826	0.04

Data are presented as mean ± standard deviation. Effect size statistics were calculated using Cohen's d for variables analysed with independent t-test and effect size r for variables analysed with the Mann-Whitney U test ([a]). Abbreviations: BMI, Body mass index; CON, Control group; d, Cohen's d; FFM, Fat-free mass; n, Number of participants in the sample; r, effect size r; SPPB, Short Physical Performance Battery; TRAIN, Training group.

[#] Significant differences when comparing training and control groups at the baseline assessment. The significance level was set at 0.05.

Table 2
Effects of exercise programme on SPPB, frailty and HRQoL by groups.

Characteristics	TRAIN (n = 59)	CON (n = 64)	*p*-Value
SPPB (pts)			
T0	7.47 ± 1.78	7.80 ± 1.72	0.298
T1	10.86 ± 1.72*	8.94 ± 2.71	<0.001#
Frailty scale (pts)			
T0	1.47 ± 1.26	1.52 ± 1.24	0.826
T1	0.80 ± 0.90*	1.41 ± 1.10	0.004#
HRQoL (pts)			
T0	0.82 ± 0.18	0.78 ± 0.19	0.216
T1	0.90 ± 0.15*	0.78 ± 0.18	0.001#

Data are presented as mean ± standard deviation.
Abbreviations: CON, Control group; HRQoL, Health-related quality of life; n, Number of participants in the sample; SPPB, Short Physical Performance Battery; T0, baseline assessment; T1, post-training assessment; TRAIN, Training group.

[#] Significant differences when comparing training and control groups at baseline or post-training assessments. The significance level was set at 0.05.

[*] Significant differences within groups between the baseline and post-training assessments. The significance level was set at 0.05.

Table 3
Cost of delivering the exercise programme.

Item	Units	Unit cost (€)	TRAIN (*n* = 59) Average per participant (€)	CON (*n* = 64) Average per participant (€)
Physical activity sessions				
Exercise equipment	4	697.68	47.30	0
Sports facilities (Hours)	288	15.00	73.22	0
Exercise coach time (Hours developing)	288	8.21	40.08	0
Exercise instructor time (Hours prescribing)	24	8.21	3.34	0
Total cost / participant			163.94	0
Cost / attended session / participant			2.74	
Total cost			9672.46	

Abbreviations: CON, Control group; n, Number of participants in the sample; TRAIN, Training group.

3.3. Cost-effectiveness and cost-utility

A summary of cost-effectiveness analysis is shown in Table 6. An ICER of €115 per point increase in SPPB, €407 per point decrease in frailty scale and €6273 per QALY gained were found according to analyses. Figs. 2A, 3A, and 4A present the cost-effectiveness plane with 5000 bootstrap simulations. Most simulations were in the northeastern part of the cost-effectiveness plane, meaning an additional cost was associated with additional health effect. Figs. 2B, 3B and 4B present the cost-effectiveness acceptability curve, showing that the probabilities of the MCT programme being cost-effective is 100 % at a WTP €1000 per point improvement in functional capacity, €3500 per point decrease in frailty status and €49,000 per QALY gained.

3.4. Sensitivity analyses

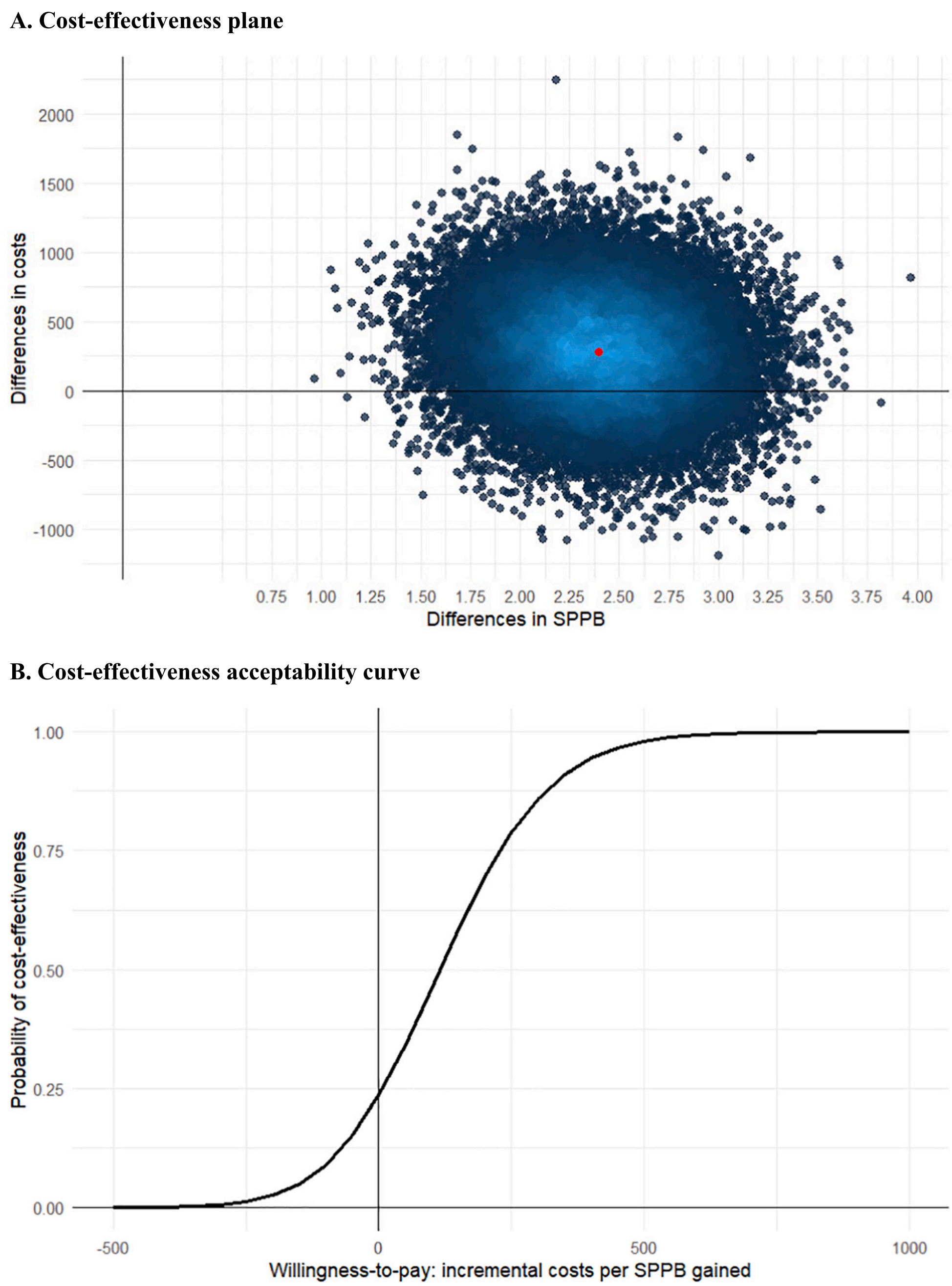

Fig. 2. Cost-effectiveness of exercise programme to usual care, including Short Physical Performance Battery (SPPB) as outcome measure. (A) Cost-effectiveness plane including 5000 bootstrap simulations. (B) Cost-effectiveness acceptability curve for change in physical functioning (willingness to pay/outcome).

A. Cost-effectiveness plane

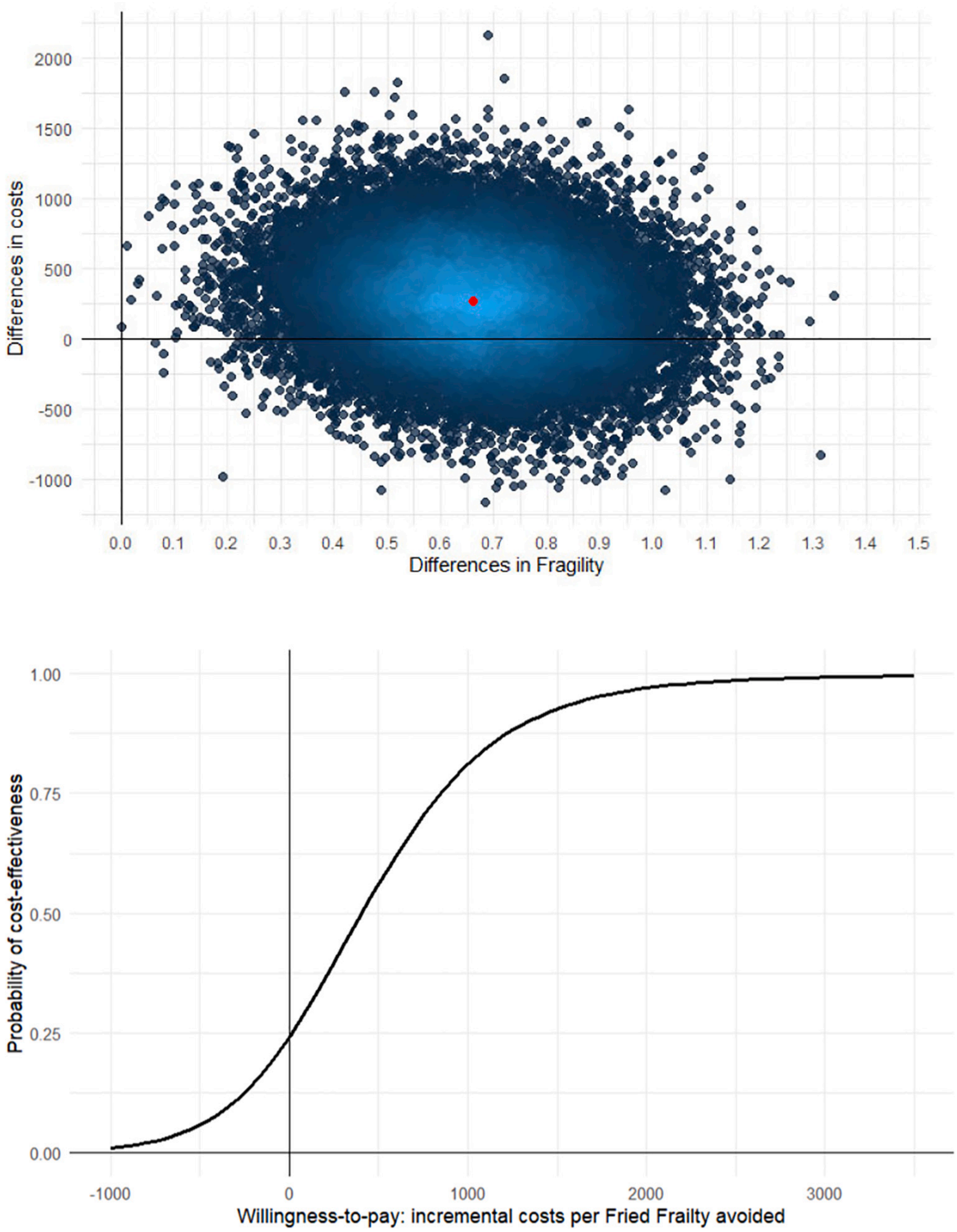

Fig. 3. Cost-effectiveness of exercise programme to usual care, including frailty as outcome measure. (A) Cost-effectiveness plane including 5000 bootstrap simulations. (B) Cost-effectiveness acceptability curve for change in frailty level (willingness to pay/outcome).

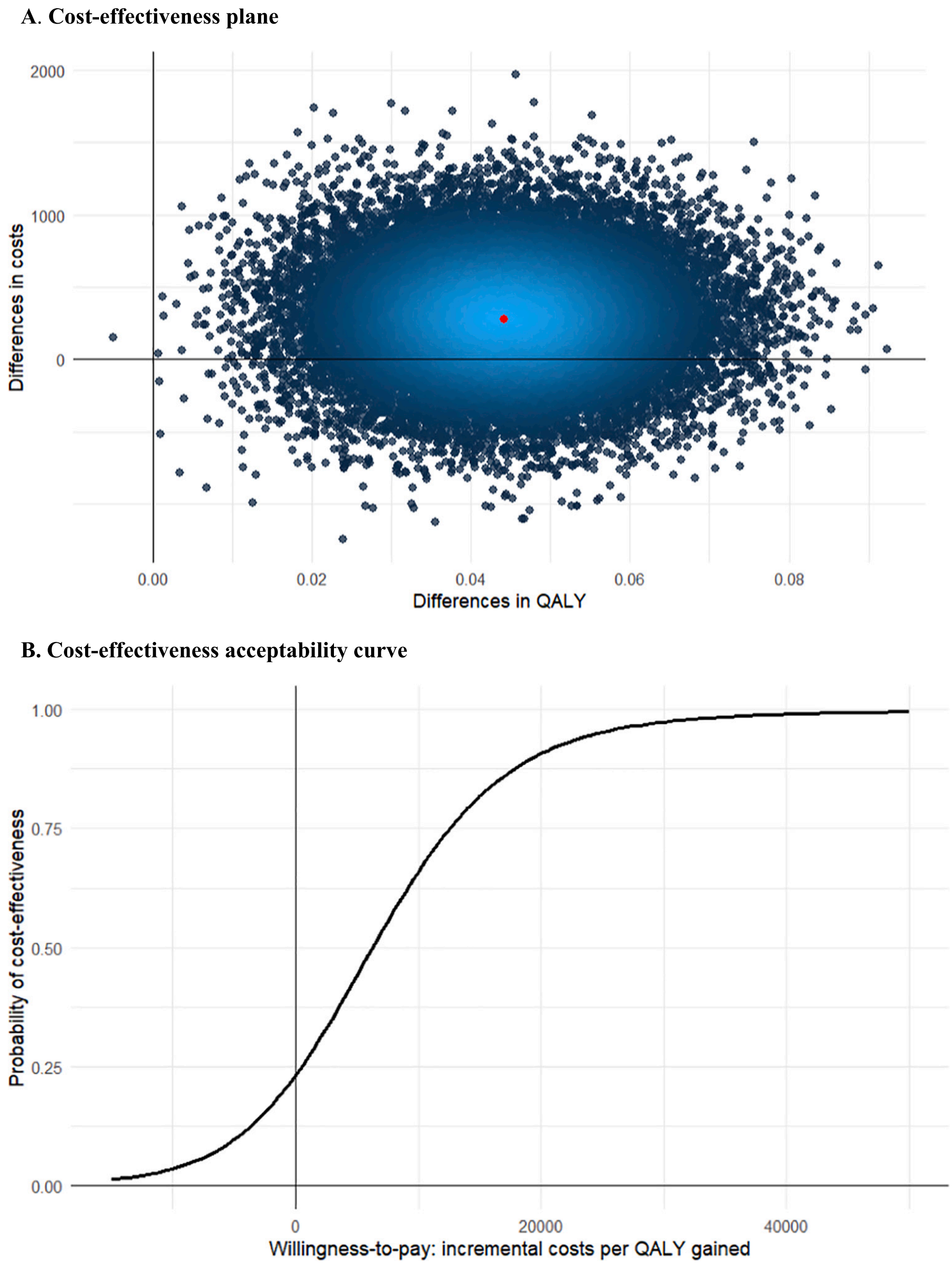

Fig. 4. Cost-effectiveness of exercise programme to usual care, including quality adjusted life-year as outcome measure. (A) Cost-effectiveness plane including 5000 bootstrap simulations. (B) Cost-effectiveness acceptability curve for change in QALY (willingness to pay/outcome).

4. Discussion

The present study demonstrated that the 6-month MCT programme delivered to older adults with decreased functional capacity had a 100 % probability of being cost-effective at a WTP threshold of €1000 per point improvement in SPPB, €3500 per point decrease in frailty score and €49,000 per QALY gained.

4.1. Effectiveness

The effectiveness of the 6-month MCT programme in improving frailty status, HRQoL, and functional capacity in older adults with decreased functional capacity has been previously reported in other manuscripts (Fernández-García et al., 2022; Moradell et al., 2023) and confirmed in the present study. Although results are broadly consistent, some variation in effect size across studies is to be expected due to differences in sample characteristics. This research employed an intention-to-treat analysis, including all 123 participants assessed, irrespective of trial completion or dropout. In contrast, the results manuscript was based on a per protocol analysis, which including 106 participants. Despite these methodological differences in sample size and analysis strategy, the findings are consistent with the precious publications (Fernández-García et al., 2022; Moradell et al., 2023), where the TRAIN group showed significant improvements in SPPB (+3.2 ± 2.4), frailty (−0.7 ± 1.3) and HRQoL (+0.07 ± 0.02), reinforcing the robustness of the MCT programme effects.

Importantly, these results are consistent with recent meta-analyses, which highlight that MCT programmes lead to significant improvements in functional capacity and frailty status among older adults. For instance, Luo et al. (Yang et al., 2024) reported that MCT was associated

Table 4
Cost of health care utilisation.

Item	Unit cost (€)	TRAIN (n = 59) Average per participant (€)		CON (n = 64) Average per participant (€)	
		Units	Total cost (€)	Units	Total Cost (€)
Direct Health Service Cost					
Primary care (Physician)	67.77	T0:131 T1: 158	T0: 8877.87 T1: 10,707.66	T0: 143 T1: 193	T0: 9691.11 T1: 13,079.61
Primary care (nurse)	31.26	T0: 42 T1: 43	T0: 1312.92 T1: 1344.18	T0: 43 T1: 53	T0: 1344.18 T1:1656.78
Specialist physician	126.81	T0: 154 T1: 157	T0: 19,528.74 T1: 19,909.17	T0: 190 T1: 187	T0: 24,093.9 T1: 23,713.47
Others*	20.08	T0: 0 T1: 0	T0: 0 T1: 0	T0: 3 T1: 0	T0: 60.24 T1: 0
Emergency rooms or urgent care	124.44	T0: 20 T1: 27	T0: 2488.8 T1: 3359.88	T0: 38 T1: 41	T0: 4728.72 T1: 5102.04
Medication			T0: 10,041.89 T1: 12,591.71		T0: 16,278.05 T1: 21,460.66
Hospital admissions	474.76	T0: 8 T1: 62	T0: 3798.08 T1: 29,435.12	T0: 100 T1: 83	T0: 47,476 T1: 39,405.08
Radiography	43.95	T0: 32 T1: 38	T0: 1406.4 T1: 1670.1	T0: 65 T1: 61	T0: 2856.75 T1: 2680.95
Ultrasound	146.45	T0: 8 T1: 10	T0: 1171.6 T1: 1464.5	T0: 13 T1: 18	T0: 1903.85 T1: 2636.1
Computed tomography	140.67	T0: 5 T1: 9	T0: 703.35 T1: 1266.03	T0: 9 T1: 7	T0: 1266.03 T1: 984.69
Magnetic resonance	401.02	T0: 3 T1: 1	T0: 1203.06 T1: 401.02	T0: 2 T1: 2	T0: 802.04 T1: 802.04
Electrocardiograph	43.95	T0: 10 T1: 28	T0: 439.5 T1: 1230.6	T0: 21 T1: 24	T0: 922.95 T1: 1054.8
Blood sample analysis	180.95	T0: 60 T1: 104	T0: 10,857 T1: 18,818.8	T0: 96 T1: 95	T0: 17,371.2 T1: 17,190.25
Urine sample analysis	95.23	T0: 22 T1: 29	T0: 2095.06 T1: 2761.76	T0: 33 T1: 38	T0: 3142.59 T1:3618.74
Blood cultures	27.33	T0: 0 T1: 0	T0: 0 T1: 0	T0: 2 T1: 2	T0: 54.66 T1: 54.66
Urine cultures	38.08	T0: 11 T1: 11	T0: 418.88 T1: 418.88	T0: 14 T1: 14	T0: 533.12 T1: 533.12
Stool cultures	71.43	T0: 2 T1:1	T0: 142.86 T1: 71.43	T0: 0 T1: 1	T0: 0 T1: 71.43
Endoscopy	292.99	T0: 3 T1: 5	T0: 878.97 T1: 1464.95	T0: 4 T1: 3	T0: 1171.96 T1: 878.97
Biopsy	126.0	T0: 3 T1: 7	T0: 378 T1: 882	T0: 4 T1: 3	T0: 504 T1: 378
Optical coherence tomography	146.47	T0: 4 T1: 4	T0: 585.88 T1: 585.88	T0: 4 T1: 1	T0: 585.88 T1: 146.47
Ergometry	146.59	T0: 0 T1: 1	T0: 0 T1: 146.59	T0: 3 T1: 1	T0: 439.77 T1: 146.59
Total cost T0			69,521.66		135,227.0
Total cost/participant T0			1178.33		2112.92
Total cost T1			112,885.0		129,437.6
Total cost/participant T1			1913.30		2022.46
Total cost			182,406,66		264,664,6
Total cost/participant			3091.64		4135.38

Abbreviations: CON, Control group; n, Number of participants in the sample; T0, Baseline assessment for 6 months; T1, post-training assessment for 6 months; TRAIN, Training group.

* Others: Physiotherapist, social worker, nutritionist and occupational therapist.

with large effects sizes in reducing frailty (−1.40) and improving muscle strength, balance, gait speed, and functional capacity as measured by SPPB. Similarly, a review by Apóstolo et al. (Apóstolo et al., 2018) concluded that structured exercise significantly improved HRQoL in pre-frail and frail populations. The magnitude of improvement in our study (SPPB: + 3.2 points; frailty: −0.7 points; HRQoL; +0.07 points) exceeds the established minimal clinically important difference (MCID) for older adults, indicating both clinical relevance and statistical robustness. Taken together, these findings support the effectiveness of the Exernet-Elder 3.0 programme as a viable intervention for mitigating frailty and functional decline in this population.

A notable point of contrast between the present study and prior research (Fernández-García et al., 2022; Moradell et al., 2023), is that, at baseline, the TRAIN group exhibited greater body mass (+5.9 kg), height (+4.2 cm), and fat- free mass (+4.1 kg) than the CON group. These differences may have influenced the outcomes of the intervention. However, disparities in body mass between groups are unlikely to have significantly affected results related to frailty status or functional capacity, as both underweight and obesity have been associated with increased frailty and poorer functional capacity, whereas maintaining a healthy weight may help prevent future frailty and support better functional capacity (Rutherford et al., 2022; Xu et al., 2020; Gajic-Veljanoski et al., 2018).

Conversely, differences in fat-free mass between groups may have

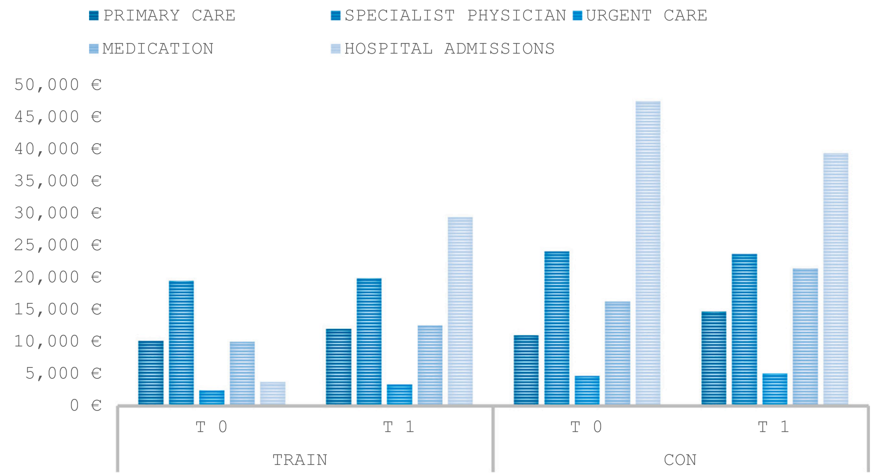

Fig. 1. Cost of health care utilisation by groups and service category at baseline and post-intervention.
Abbreviations: CON, Control group; T0, Baseline assessment for 6 months; T1, post-training assessment for 6 months; TRAIN, Training group.
Notes: Primary care includes cost of physician and nurse practices.

Table 5
Total cost of delivering exercise programme and direct health service per participant.

Item	TRAIN (n = 59) Average per participant (€)	CON (n = 64) Average per participant (€)
Exercise programme	163.94	0
Direct Health Service T0	1178.33	2112.92
Direct Health Service T1	1913.30	2022.46
Total cost/participant	3255.57	4135.38
Total cost	192,078.63	264,664.32

Abbreviations: CON, Control group; n, Number of participants in the sample; T0, Baseline assessment for 6 months; T1, post-training assessment for 6 months; TRAIN, Training group.

contributed to the observed effects. A recent systematic review and meta-analysis of prospective studies demonstrated that lower muscle mass is associated with a higher risk of functional decline in older adults (Visser et al., 2025). Similarly, the FRASNET study (Damanti et al., 2024), which assessed frailty in community-dwelling Italian older adults, identified sarcopenic obesity and pre-sarcopenia as a modifiable predictor of both frailty and frailty stage.

In contrast, it appears that the height in older people is not associated with functional capacity or frailty (Easton et al., 2018); nonetheless, further studies is warranted to clarify any potential relationship.

4.2. Health care utilisation

The Exernet-Elder 3.0 project demonstrated a reduction in health care utilisation among older adults participating in the MCT programme compared to the CON group. The TRAIN group reported a minor increase in the frequency of primary care visits and a lower number of days spent in hospitalisations throughout the intervention, averaging 1.5 fewer days per participant annually. This aligns with findings from the LIFE study, which was focused primarily on walking, with secondary components of strength, flexibility, and balance training, where participants in a PA intervention accrued lower medical costs compared to health education groups, with an average difference of $3302 per participant over 2.6 years (Groessl et al., 2016). Similarly, the REACT programme, which combined multimodal exercise, social and

Table 6
Results of cost-effectiveness analyses SPPB, frailty and QALY as outcome measure from the healthcare perspective.

Item	Incremental effect	Incremental cost €	ICER € /Outcome
SPPB	2.40 (1.63–3.16)	275.99	115.21
Frailty scale	0.66 (0.31–1.01)	268.64	407.01
QALY	0.04 (0.02–0.07)	276.78	6273.78

Abbreviations: ICER, incremental cost-effectiveness ratio; n, Number of participants in the sample; QALY, Quality adjusted life years; SPPB, Short Physical Performance Battery.

educational components designed to improve strength, balance, mobility and maintenance of healthy behaviours, showed that reductions in health and social care utilisation could offset the intervention delivery costs, leading to a cost-neutral or cost-saving scenario in the long term (Snowsill et al., 2022). From a broader perspective, the ProMuscle intervention, which combined resistance exercise with dietary interventions, also reported meaningful reductions in health care use despite no significant change in QALYs (Dorhout et al., 2021). This consistency across studies underlines the potential of structured PA programmes to mitigate the high health care costs associated with ageing and frailty. However, variability in reporting and cost measurement methodologies highlights the need for standardisation in future economic evaluations.

Although the TRAIN group generally showed lower costs compared to the CON group, a closer examination within the TRAIN group reveals an unexpected finding: direct health service cost increase from T0 to T1. This apparent contradiction can be explained by several factors. First, the main contributors to the increased expenditure were hospital admissions and blood tests. Two participants were hospitalized for 21 and 16 days, respectively, due to unrelated medical conditions with the MCT programme, resulting in substantial individual cost increases (€9970 and €7596). Second, participants in the TRAIN group appeared to become more aware of their health status during the exercise programme, which led to more physician visits and diagnostic tests, particularly blood tests. Third, six months might be too short to see the full benefits, like fewer emergency visits or delayed need for long-term care. Longer studies are needed to capture these effects. Fourth, some healthcare use during T1 could be from previously scheduled appointments or delayed procedures, not the intervention itself. Finally, the non-randomised allocation of participants introduces baseline differences in healthcare costs that may have resulted in residual confounding, despite statistical adjustments. These findings highlight the importance of interpreting short-term economic outcomes with caution and highlight the importance of conducting future randomised controlled trials with extended follow-up periods.

4.3. Intervention costs

The cost of implementing the Exernet-Elder 3.0 MCT programme was calculated at €163.94 per participant over six months, which includes personal costs, equipment, and facility use. When compared to other interventions, such as the REACT programme (£622 per participant) and the LIFE study ($3302 per participant over 2.6 years), the Exernet-Elder 3.0 programme appears cost-competitive (Groessl et al., 2016; Snowsill et al., 2022). Furthermore, the ProMuscle study total cost of €2988 per participant for a combined dietary and exercise programme over 24 weeks demonstrates the efficiency of simpler, scalable interventions like Exernet-Elder 3.0 (Dorhout et al., 2021).

A closer examination of intervention cost structures reveals key areas for optimisation. For example, the REACT programme allocated £309 per participant to session leader time and £109 to venue hire, while the LIFE study incurred higher costs due to the inclusion of both centre-based and home-based components (Groessl et al., 2016; Snowsill et al., 2022). Similarly, cost reductions in the Exernet-Elder 3.0 project could be explored by leveraging community-based resources or virtual training formats, as seen in the home-exercise programme for post-hospitalisation older adults, which demonstrated cost-effectiveness with an average cost of $751 per participant (Farag et al., 2015).

The cost analysis presented in this study reveals lower overall expenses compared to similar exercise programs reported in countries such as Australia, the USA, and the UK. This difference is largely attributable to the regional economic factors, including lower labour costs for sport scientist, access to municipal sports facilities, and how equipment is purchased through research group. Additionally, delivering the programme in a group-based format optimised the use of instructor's time, further enhancing cost efficiency. Importantly, the intervention achieved a high attendance rate of 83 %, with an estimated cost of € 2.74 per attended session per participant, underscoring both the feasibility and cost-effectiveness of the programme in real-world conditions. These factors contribute to the affordability of the MCT programme within the Spanish context. However, caution is warranted when generalising these cost findings to other countries with different labour markets, facility access, or healthcare systems structures. Further economic evaluations in diverse settings are needed to better understand cost variability and inform the broader implementation of similar interventions.

4.4. Cost-effectiveness and cost-utility

The Exernet-Elder 3.0 MCT programme showed a remarkable cost-effectiveness profile, particularly in improving functional capacity. The ICER for the intervention was calculated at €115 per point increase in the SPPB. This value significantly outperforms results from similar interventions. For instance, the ProMuscle study, which combined resistance exercise with dietary strategies, reported an ICER of €2988 per SPPB point increase (Dorhout et al., 2021). Similarly, the Farag et al. study identified an ICER of $22,958 per participant achieving mobility improvement within their home-exercise programme for older adults (Farag et al., 2015). Likewise, the LIFE study, focusing on mobility disability prevention, reported an ICER of $42,376 per major mobility disability prevented, indicating higher costs for similar functional outcomes (Groessl et al., 2016). In comparison, the Exernet-Elder 3.0 programme highlights the economic viability of structured, group-based exercise programmes for functional decrease prevention.

For frailty status improvement, the Exernet-Elder 3.0 intervention demonstrated an ICER of €407 per point decrease on the frailty scale. Comparable data from the Fairhall study indicate a cost of AUD $15,955 for one participant transitioning out of frailty, emphasising the relative efficiency of Exernet-Elder 3.0 (Farag et al., 2015).

These results demonstrate the utility of MCT programmes as cost-effective tools for enhancing physical function and reducing frailty in older adults. The comparatively low ICERs suggest that this programme can be used as a benchmark for future interventions targeting ageing-related health decline.

5. Cost-utility analysis

The Exernet-Elder 3.0 programme yielded an ICER of €6274 per QALY gained, placing it well below the accepted thresholds for cost-effectiveness in Spain (€27,000–€34,000 per QALY) and other high-income countries, such as the UK (£20,000–£30,000 per QALY) and the USA ($50,000 per QALY) (Subías-Perié et al., 2022a; Drummond et al., 2015). This ICER demonstrates that the intervention offers substantial value for health system investments.

When compared to other programmes, such as the OnTrack chemotherapy exercise intervention (ICER €26,916/QALY) (van Waart et al., 2018), and the LIFE study ($49,167/QALY over 2.6 years) (Groessl et al., 2016), Exernet-Elder 3.0 provides a competitive alternative for improving HRQoL in older adults. Additionally, systematic reviews support the inclusion of progressive, MCT programmes with moderate-to-vigorous intensity, as these are associated with higher QALY gains and lower ICERs compared to single-modality programmes (Subías-Perié et al., 2022a).

Sensitivity analyses confirmed the robustness of the Exernet-Elder 3.0 ICERs, remaining below cost-effectiveness thresholds across variations in adherence and programme delivery costs. Findings from McLean et al. emphasise the potential of cost-sharing models to further enhance scalability while maintaining cost-effectiveness (Farag et al., 2015).

5.1. Limitations of the study

This study, while providing moderate evidence for the cost-effectiveness and utility of the Exernet-Elder 3.0 MCT programme, is subject to several limitations:

- Firstly, the generalisability of the findings is limited by the relatively homogeneous nature of the study population, which primarily included older adults from a single geographic region and cultural context. This limitation may limit the generalizability of the findings to broader populations. Cultural, social, genetic and economic factors can influence ageing trajectories, health behaviours, and functional outcomes, potentially affecting how frailty and physical performance manifest in different contexts. Therefore, caution is warranted when extrapolating these findings to populations with differing sociodemographic characteristics and health profiles.
- Secondly, participants were not randomly allocated to groups, but assigned based on convenience, which may have introduced selection bias and contributed to baseline differences between groups. Although statistical adjustments were applied, residual confounding cannot be ruled out. Future studies employing randomised controlled trial designs are needed to strengthen internal validity and provide more robust evidence.
- Thirdly, the follow-up period of six months, while sufficient to capture short-term outcomes, limits our ability to assess the long-term sustainability of the benefits of the intervention and its economic impact over time. Previous studies have shown that the positive effects of MCT programmes—such as improvements in functional capacity, frailty reduction, and cost-effectiveness—can be sustained or

evolve over periods of 12 to 30 months (Subías-Perié et al., 2022a; Freiberger et al., 2012). Longer follow-up durations are therefore essential to determine whether the observed benefits are maintained, decline, or increase over time, and whether delayed cost savings emerge because of reduced healthcare utilisation or postponed institutionalisation. Future trials should incorporate extended follow-up to provide a more comprehensive assessment of both health and economic outcomes.
- Fourth, the baseline imbalance between groups in the cost of health care utilisation should be highlighted, as this may affect the interpretation of cost-effectiveness results.
- Fifth, reliance on self-reported measures for health care utilisation introduces potential recall bias, which may have influenced the accuracy of the cost estimates. Although this approach is common in economic evaluations, the potential for underreporting or misreporting remains. Future studies should consider validating self-reported data with objective sources to enhance the robustness of economic analyses. In the present study, electronic health records and administrative databases were used to obtain information; however, the use of self-reported measures was also necessary.
- Sixth, although the analysis considered health outcomes within a 10-month period, it is likely that the exercise program also produced indirect or delayed benefits that were not captured in our results. These may include reduced risk of falls, chronic disease progression, or functional decline, which are well-documented effects of exercise intervention in older adults (Bouaziz et al., 2016; Subías-Perié et al., 2024; Fernández-García et al., 2022). Therefore, the estimated cost-effectiveness may be conservative. This is consistent with findings from a recent systematic review by Chase et al. (Chase et al., 2025), which reported that exercise programs across diverse populations and setting generated positive returns on investment and cost savings though improved chronic disease management and reduced healthcare utilisation. Longer-term evaluations would be needed to fully capture these extended benefits and provide a more comprehensive economic assessment.
- Finally, while efforts were made to adopt a comprehensive perspective, certain indirect or societal costs - such as caregiver burden, informal care, and societal productivity losses - were not fully captured. These factors represent important components of the broader economic impact of intervention in older adults. This exclusion may underestimate the total economic impact of the intervention from a societal perspective.

5.2. Future lines of research

Building on the insights gained from this study, future research should aim to address the identified limitations and further explore the potential of MCT programmes. Longitudinal studies with extended follow-up periods are necessary to assess the long-term cost-effectiveness and health outcomes of such interventions. Moreover, expanding the scope of research to replicate and validate these findings in more diverse and multicultural populations will enhance the generalisability of the results, improve understanding of the intervention's external validity and applicability, and support the development of tailored strategies. To improve methodological accuracy, future studies should also consider validating self-reported healthcare utilisation data against objective records, which would help to minimise recall bias and strengthen the reliability of cost-effectiveness estimates. Additionally, incorporating digital or hybrid delivery models - such as tele-programmes or virtual coaching- could reduce implementation costs while maintaining programme efficacy. Future studies should aim to incorporate a broader societal perspective in economic evaluation, integrating indirect or societal costs such as informal care and caregiver burden, to provide a more complete and realistic estimation of the economic impact of MCT programmes, particularly in older adults where informal support networks play a critical role. Furthermore, some future research could focus on the cost-effectiveness of stratified exercise rehabilitation programmes for people with chronic diseases, as well as on evaluating different exercise protocols to optimize clinical and economic outcomes. Finally, qualitative research exploring participant and caregiver experiences can offer valuable insights into programme adherence and acceptability, supporting its integration into routine health care strategies.

6. Conclusions

The findings of this study confirm the Exernet-Elder 3.0 MCT programme as a highly cost-effective intervention for older adults with decreased functional capacity, offering a significant improvement in functional performance, frailty reduction, and QALYs at costs well within accepted thresholds. Specifically, the programme demonstrated an ICER of €115 per point increase in the SPPB, €407 per point decrease in the frailty scale, and €6274 per QALY gained, outperforming similar interventions reported in the literature. These results underline the importance of integrating structured, group-based exercise regimens into public health strategies to address the growing socioeconomic and health burden associated with ageing populations. The robust economic and health benefits presented here support the widespread adoption of the Exernet-Elder 3.0 programme as a cornerstone for promoting healthy ageing and functional independence.

Considering these findings, it is essential that MCT programmes be supported by policymakers and integrated into healthcare systems and community-based care models. Their implementation should be carried out coordinated with medical doctors, clinical exercise physiologist, and specialized sports scientist to ensure safety, effectiveness, and participant adherence. Exercise should be considered a clinically relevant therapeutic strategy for the management of chronic diseases and for reducing healthcare expenditure. Consequently, governments should support the creation of permanent positions for clinical exercise physiologists and sports scientists within healthcare and community settings, thereby ensuring the long-term sustainability and scalability of such evidence-based interventions.

CRediT authorship contribution statement

J. Subías-Perié: Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **D. Navarrete-Villanueva:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Data curation. **A.I. Fernández-García:** Writing – review & editing, Validation, Supervision, Investigation, Data curation. **A. Moradell:** Writing – review & editing, Validation, Supervision, Investigation, Data curation. **J.T. Alcalá-Nalvaiz:** Writing – review & editing, Formal analysis, Data curation. **E.J. Groessl:** Writing – review & editing, Methodology. **I. Ara:** Writing – review & editing, Resources, Funding acquisition. **S. Vila-Maldonado:** Writing – review & editing. **J. Pérez-Gómez:** Writing – review & editing, Resources, Methodology. **M. Gonzalez-Gross:** Writing – review & editing. **A. Gómez-Cabello:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **G. Vicente-Rodríguez:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **J.A. Casajús:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Hospital Universitario Fundación Alcorcón Ethics Committee (Spain) (16/50).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data that has been used is confidential.

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