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The role of physical exercise in enhancing Health, quality of life and joy among older adults

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Physical exercise (PE) plays a vital role in promoting health, quality of life (QoL), and well-being in older adults. It helps prevent chronic diseases, improves strength, balance, and cognitive function, and reduces fall risk. Enjoyment and psychological engagement are also essential for long-term adherence. This randomized controlled trial (RCT) study aimed to examine the effects of a 24-week structured sensorimotor training program on physical activity (PA) levels, body composition, quality of life, and enjoyment in older adults. A total of 124 participants (65–80 years old) were allocated to an experimental group (EG, n = 46) or control group (CG, n = 78). The EG engaged in a 24-week supervised sensorimotor training program, while the CG maintained their usual lifestyle. PA levels were assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF); enjoyment of PA was evaluated using the Physical Activity Enjoyment Scale (PACES); and QoL was measured with the SF-36 questionnaire. Body composition, PA, and QoL were evaluated at baseline and post-intervention. Both groups showed small reductions in body composition measures. The only statistically significant difference was observed in walking activity (minutes per week), with $p = 0.022$ and partial eta squared ($P\eta^2$) = 0.148, favoring the EG. No significant differences were found for overall PA levels, PACES scores, or SF-36 dimensions. Effect sizes for other outcomes ranged from $P\eta^2$ = 0.001 to 0.148, with p values ranging from 0.022 to 0.78. While the sensorimotor training program was associated with improved walking activity, no significant differences were found for other measured outcomes. The results suggest that moderate PA programs may yield selective benefits in older adults. Further research with longer follow-up and enhanced focus on motivational and psychosocial components is recommended.

Keywords Aged, Physical activity, Sensorimotor training, Quality of life, Exercise, Randomized controlled trial, Physical fitness, Enjoyment

Abbreviations

BMI	Body Mass Index
CG	Control Group
EG	Exercise Group
ES	Effect Size
HRQoF	Health-Related Quality of Life
IPAQ	Physical Activity Questionnaire Short Form
MVPA	Moderate-to-Vigorous-Intensity to Physical Activity
PA	Physical Activity
PACES	Physical Activity Enjoyment Scale
RCT	Randomized Controlled Trial
QoL	Quality of Life
SF	36-36-Item Short-Form Survey
WHO	World Health Organization

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The phenomenon of population aging has emerged globally due to increased life expectancy and declining fertility rates. Aging is a gradual, permanent, natural, and progressive process that leads to physical and mental changes, which can affect key areas of daily functioning. These include reduced mobility, diminished autonomy in performing daily activities, challenges in maintaining social relationships, and decreased ability to adapt to environmental and technological changes. However, aging also presents opportunities to promote active and meaningful lives. A comprehensive approach to healthy aging must consider not only physical health but also emotional well-being, cognitive vitality, and social participation. Maintaining interpersonal relationships, engaging in community activities, and preserving autonomy are crucial factors in supporting the health and dignity of older adults[1,2].

The concept of "quality of life" (QoL) can be viewed from multiple perspectives, with one approach emphasizing its multi-contextual nature—defined and assessed through both objective conditions and subjective evaluations. QoL encompasses physical, emotional, and social domains and significantly influences a person's overall health. For older adults, key physical aspects, such as energy levels, ability to perform daily tasks, and absence of pain, are vital. The extent to which these factors are affected varies based on lifestyle, environment, and the degree of capacity decline they experience[1].

The positive impact of regular physical activity (PA) on health and QoL in older adults is well-documented. PA plays a key role in healthy aging and helps prevent chronic diseases while reducing frailty and fall risk and preserving physical function (e.g., walking speed, handgrip strength). It also supports healthier body composition, reflected in weight, waist circumference, and body mass index (BMI) measurements. Beyond physical benefits, regular PA also contributes to improved emotional well-being, increased self-esteem, and stronger social ties. However, accurate PA monitoring is needed to better understand its link to health outcomes[3,4].

Promoting PA is essential for public health. The World Health Organization (WHO) recommends at least 150 min of moderate-to-vigorous-intensity PA (MVPA) per week. Assessing PA helps estimate the risk of disability and healthcare needs in older adults by preventing disability caused by chronic diseases or functional decline. PA is recorded using either self-reported methods or objective monitors. Self-reported tools, such as questionnaires, offer broad data collection and greater feasibility, while objective devices like pedometers and accelerometers provide more accurate activity tracking[5,6].

While both objective and subjective tools exist for population studies, much of the research relies on subjective self-report methods (e.g., questionnaires, logs, recalls). Recalling PA can be cognitively challenging for older adults, leading to issues with memory, response accuracy, and question interpretation, which reduce the validity of self-reported daily activities. Despite this, self-report methods are cost-effective and practical for large-scale studies. Additionally, surveys provide detailed information on the type (e.g., recreational, household, work-related) and duration (e.g., minutes per day or week) of PA [7].

In this study, we employed three validated instruments—IPAQ-SF to assess physical activity levels, SF-36 to evaluate health-related quality of life, and PACES to capture enjoyment of physical activity. These tools were chosen for their established reliability and validity in older adult populations and their collective ability to explore the behavioral and psychosocial dimensions of PA participation. Importantly, enjoyment has been shown to mediate and predict sustained engagement in PA, while both enjoyment and PA level are associated with higher perceived QoL in aging populations. This theoretical interrelation forms the rationale for combining these instruments in our study framework.

The International Physical Activity Questionnaire Short Form (IPAQ-SF) is well-suited for large-scale population studies on PA in adults. It measures PA across three domains: walking, moderate-intensity PA, and vigorous-intensity PA. Although the IPAQ-SF's validity has been confirmed even in older adults, it tends to overestimate time spent in all PA intensities. Additionally, the IPAQ-SF and objective measurements aligned in identifying individuals meeting WHO-recommended PA levels in only 40% to 46% of cases health[8,9]. Despite this limitation, the IPAQ-SF demonstrates acceptable convergent validity with objective tools such as accelerometers, particularly at the group level, and shows sensitivity to population variations, making it a valuable tool in epidemiological research. It has proven useful in studying the relationship between PA and older adults QoL, metabolic syndrome, sarcopenia, and mental[10].

In recent years, interest in assessing QoL has grown significantly, leading to the development of various scales and questionnaires. According to bibliographic research, the SF-36 Health Questionnaire is the most widely used tool for evaluating health-related QoL (HRQoL). This questionnaire has been adapted for diverse research, clinical, and social intervention settings. It has been applied to both the general population and individuals with health conditions. It is regarded as a reference standard for the development or validation of other HRQoL measurement tools[1,11].

Enjoyment, defined a multidimensional affective response encompassing joy, satisfaction, and psychological well-being, is a significant predictor of participation in PA. In this context, enjoyment reflects a positive attitude towards engaging in PA. Research has linked enjoyment to various psychological and behavioral traits among exercise participants, including intrinsic motivation, commitment, persistence, well-being, and adherence[12]. Self-Determination Theory (SDT), developed by Ryan and Deci[13], offers a theoretical framework for understanding intrinsic motivation. According to SDT, motivation is enhanced when three basic psychological needs are fulfilled: autonomy (feeling in control of one's actions), competence (feeling effective), and relatedness (feeling connected to others). The extent to which PA fulfills these needs plays a vital role in generating enjoyment and sustaining motivation. Meeting these needs fosters what is referred to as "optimal motivational functioning[14].

Autonomous or self-determined motivational forms are associated with more adaptive behavioral patterns characterized by higher effort and persistence. Exercise motivated by intrinsic rewards represents the highest level of self-determination, as individuals engage in PA because they genuinely enjoy it. Consequently, higher self-determined motivation is linked to positive emotions contributing to overall well-being[15,16].

The Physical Activity Enjoyment Scale (PACES), originally an 18-item measure, was designed to assess satisfaction with PA. Mullen et al.[17] recently confirmed an 8-item version using older adults in a year-long fitness program. However, the measurement characteristics of PACES across different fitness categories remain unclear, which is unfortunate given its potential to predict adherence to group exercise regimens and evaluate satisfaction in such programs.

Despite extensive evidence supporting PA in aging populations, relatively few interventions have explicitly examined how structured sensorimotor training impacts enjoyment, PA levels, and QoL in combination. Sensorimotor exercises target coordination, balance, and neuromuscular control—elements critical to maintaining autonomy in older age.

This study aimed to examine the effects of a sensorimotor physical training program on health outcomes and quality of life in older adults, as well as the mediating role of exercise enjoyment and activity levels.

We hypothesized that (1) participants in the experimental group would exhibit significantly greater improvements across these outcomes than those in the control group, and (2) higher enjoyment and PA levels would be associated with better QoL post-intervention.

This study used a two-group pre-post RCT design; thus, while correlational links between enjoyment, PA, and QoL were explored, causal mediation effects were not formally tested.

Methods

Experimental design

This study is a parallel-group, randomized controlled trial designed to assess changes in functional capacity among older adults following a 6-month physical activity (PA) intervention. The trial evaluates the longitudinal effects of a sensorimotor exercise program on physical and psychological health parameters[18].

The study was developed under the premises of the Declaration of Helsinki[19], being approved by the Bioethics Committee of the University of Évora (Registration number 21040) and developed under the ethical standard for sports science research[20]. The study was registered with the Clinical Trials.gov PRS Protocol Registration and Results System (Registration Number: NCT05398354; https://www.clinicaltrials.gov/ct2/show/NCT05398354?term=NCT05398354&draw=2&rank=1.

Participants

Sample size calculations were performed using the G*Power 3.1.9.4 software (Kiel University, Kiel, Germany), selecting the statistical test to compare the differences between groups. Thus, accepting an alpha risk of 0.05 and assuming a moderate ES of 0.4, a total of 112 participants were sufficient to reach a minimum potency of 95%. From a total of 160 regular participants in the program, this study included 124 subjects aged between 55 and 80 years. The study population comprised individuals residing in Portugal, specifically in the municipality of Almada. All participants were community-dwelling older adults who met the study's inclusion criteria. Participants were randomly assigned to the experimental or control group using computer-generated randomization with stratification based on age and baseline functional capacity. To minimize expectancy bias, participants were informed about the general objectives of the study but blinded to the specific purpose of the group comparisons. Additionally, researchers responsible for data analysis were blinded to group allocation. A parallel-group randomized controlled trial was conducted, with a 6-month intervention phase. Figure 1 describes the study design and particularities associated with each group.

A total of 124 community-dwelling adults aged 55 to 80 years participated. Participants were randomly allocated (simple randomization using computer-generated sequences) into an experimental group (EG) or a control group (CG). Assessments were conducted at baseline and post-intervention (6 months later). Inclusion criteria included: (1) age 55–80 years; (2) no major surgical procedures in the past 6 months; (3) ability to engage in physical exercise; (4) sufficient literacy to comprehend study materials and complete self-report questionnaires independently; and (5) functional independence in daily living activities, as self-reported. Exclusion criteria included: (1) diagnosed musculoskeletal, cardiovascular, psychiatric, or neurological conditions; (2) impaired mobility; (3) uncorrected sensory deficits (vision or hearing) that would interfere with participation; and (4) cognitive impairments that could hinder understanding of instructions or completion of assessments (e.g., a known diagnosis of dementia or observed difficulties during screening).

This information ensures that participants were capable of safely engaging in the intervention and accurately reporting their experiences. Baseline and post-intervention measurements included physical activity levels, quality of life, body composition, and enjoyment of physical activity, enabling the evaluation of changes in participant outcomes over time.

Baseline differences between the experimental and control groups were assessed using independent samples t-tests for continuous variables to confirm initial group comparability. No statistically significant differences were found at baseline.

Intervention

Intervention content

The sensorimotor training intervention was carried out over a period of 24 weeks, consisting of two 45-minute sessions per week, totaling 48 sessions. Each session followed a standardized format and was conducted in small groups of 6 to 10 participants, supervised by trained exercise professionals specializing in fitness for older adults. Each session included three phases: warm-up (10 min): Gentle aerobic exercises such as walking in place, arm circles, and shoulder rolls, followed by dynamic stretching and mobility movements targeting the major joints (e.g., hips, knees, shoulders); main exercise circuit (25 min): Participants completed a circuit of 8 exercises, each performed for 50 s, with 10 s allocated for transitioning between exercises. The full circuit was repeated four times, totaling approximately 30 min of active work within the main phase; cool-down (10 min): This

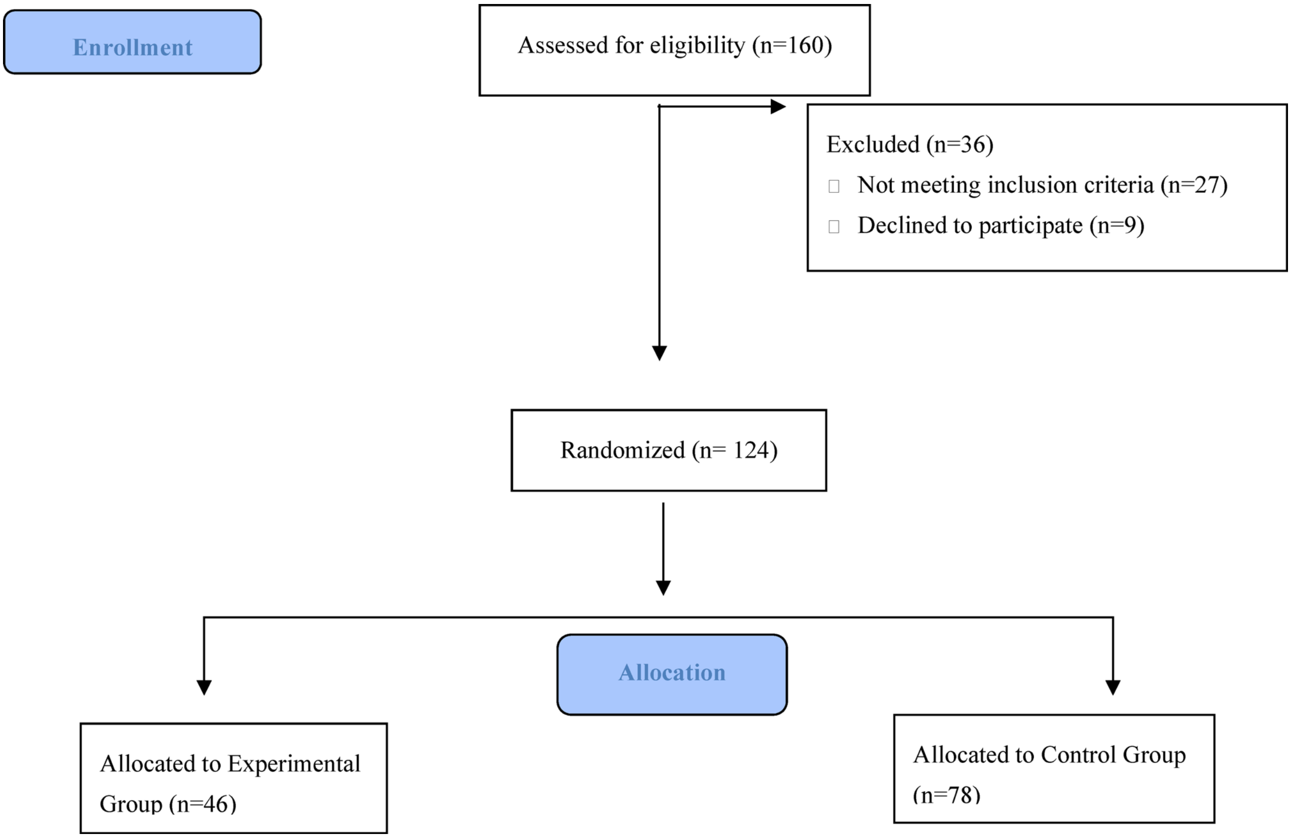

Fig. 1. Study design and groups characterization.

phase focused on stretching the major muscle groups, breathing control, and relaxation techniques to facilitate recovery and promote flexibility.

The intervention was progressively structured into three 8-week phases, each with increasing complexity and intensity: phase 1 (Weeks 1–8 – Easy): Exercises were performed using body weight only, focusing on postural control and basic balance. Activities included tandem stance, sit-to-stand transitions, arm swings with trunk rotation, and single-leg standing with visual fixation; phase 2 (Weeks 9–16 – Intermediate): Moderate external resistance was introduced using elastic resistance bands, light dumbbells (0.5–2 kg), and balance cushions. The exercises incorporated dual-task challenges such as coordination tasks (e.g., walking while clapping or counting backwards) and dynamic movements like lateral stepping and object transfers; phase 3 (Weeks 17–24 – Advanced): Exercises were further intensified by increasing external loads and including unstable surfaces such as foam pads or BOSU balls. Complex motor tasks involving multi-directional movement, obstacle navigation, and cognitive-motor dual-tasks (e.g., naming categories while performing step-ups) were added to enhance proprioception, agility, and cognitive engagement.

Exercise progression was individualized based on participant performance, balance control, and perceived exertion. Instructors followed pre-established criteria to ensure consistent delivery while allowing adaptations when needed to maintain safety and motivation. Participants could choose simpler variations of exercises when appropriate. To ensure standardization, a detailed training manual was provided to all facilitators, and weekly team meetings were held to review session fidelity and adjust activities as needed. Safety was prioritized by using non-slip flooring, accessible handrails, and real-time monitoring during sessions. A variety of accessible equipment—such as elastic bands, light hand weights, cones, balance discs, chairs, foam rollers, and unstable platforms—was incorporated to provide diverse sensorimotor stimuli.

Prior to the intervention, all participants attended a familiarization session to become acquainted with the exercises, equipment, and training structure, aiming to increase comfort and reduce potential instrumentation bias. The intervention was implemented by two certified exercise technicians who received specific training to ensure high fidelity to the protocol, under the supervision of a project coordinator. Notably, the same technicians conducted the outcome assessments but were blinded to group allocation to reduce potential bias[21]. Participants in the control group received standard care and were only involved in baseline and post-intervention assessments; they did not participate in any structured exercise program during the study period.

Measures:

A variety of tools were used for the assessments under study. All measures were taken at baseline, at the end of the intervention. Before the first measurement, all participants were involved in a familiarization phase to adapt themselves to the different instruments and assessments included in this project. To assess the physical fitness of the participants they wore tracksuit bottom and were asked to remove accessories and any objects in their pockets. The following measures were carried out:

a. Anthropometrics and body composition. Bodyweight and height were assessed. Before the measurements, participants were asked to remove their shoes, socks, and heavy clothing (coats, sweaters, coats, etc.). They were also asked to empty their pockets and remove belts and other accessories (bands, pendants, etc.). Height was measured using a stadiometer (Seca 22, Hamburg, Germany). This instrument was placed on a vertical surface with the measuring scale perpendicular to the ground. Participants were positioned in a standing position, with their shoulders balanced, and their arms relaxed along their body. Height was taken in cm and rounded to the nearest mm. Body weight was measured using a scale. Body weight was determined in kg. and the BMI using the formula: weight (kg)/height^2 (m^2).
b. Health-related quality of life assessed with the SF-36 Portuguese version[22–24], a 36-question tool, which results in 8 dimensions of health status (physical function, physical role, bodily pain, general health, vitality, social function, emotional role, and mental health) and 2 summary components (physical and mental). Dimensions and components are scored from 0 to 100, where 0 is the worst state, and 100 is the best.
c. Physical Activity Level assessed with IPAQ-SF[8]. This instrument consists of four questions informing on the frequency (days/week) and duration (minutes/day) of daily walks and activities requiring moderate to vigorous physical exertion, as well as the time (minutes/day) spent on sitting activities on weekdays and weekends. PA was classified into three categories according to the IPAQ consensus group: sedentary (< 600 Met-minutes/week), active (≥ 600 Met-minutes/week), and very active (≥ 3000 Met-minutes/week). This instrument was completed by the participants in its Portuguese version[25].
d. Exercise enjoyment was assessed with the 8-item Portuguese version of the Physical Activity Enjoyment Scale (PACES), a validated and widely used instrument for measuring subjective enjoyment of physical activity in adults and older populations. It consists of 8 items rated on a 7-point bipolar scale (where 1 = "I like it" and 7 = "I hate it", with 4 = "neutral"), capturing participants' affective response to the exercise experience. Total scores range from 8 to 56 points, with higher scores indicating greater enjoyment. The Portuguese adaptation of PACES has demonstrated acceptable internal consistency and construct validity in older Portuguese adults. The scale was administered to all participants in the experimental group at baseline and post-intervention to evaluate changes in exercise enjoyment[16].

Statistical analysis

Normality of data distribution was verified using the Kolmogorov–Smirnov test[26]. Parametric tests were applied[27]. Descriptive statistics (mean ± SD) were calculated. Between-group differences were analyzed using independent samples t-test, with group (EG vs. CG) as the between-subject factor and time (pre vs. post) as the within-subject factor. Treatment effect was estimated as $\Delta = [(\text{Post} - \text{Pre})/\text{Pre}] \times 100$. Effect sizes (ES) were calculated using both partial eta squared ($P\eta^2$) with thresholds for $P\eta^2$ of 0.01 (small), 0.06 (moderate), and 0.14 (large)[28]. Where appropriate, 95% confidence intervals (CIs) were also reported to provide precision of the estimates. Analyses were performed using Jamovi 2.5.2.0. Significance level set at $p < 0.05$.

Results

Participant details

Table 1 shows the characteristics of the sample to contextualize and framework the sample used in the study.

Table 1. Characteristics of participants at the baseline.

According to the results, the 124 participants were of similar ages. In terms of weight and height, they were similar, both being overweight[29].

Body composition, physical activity, and health-related quality of life

Regarding body composition, the BMI results of both groups decreased from baseline to the following 24 weeks, with the EG having a greater reduction (Table 2). There were no significant differences in this variable ($p = 0.141$). It also has a small ES ($P\eta^2 = 0.018$).

	EG *N* = 46	CG *N* = 78	*p*
Age (years)[a]	72.40 ± 6.90	73.20 ± 5.80	0.505
Weight (kg)[a]	68.40 ± 14.20	71.30 ± 13.40	0.257
Height (m)[a]	1.57 ± 0.08	1.58 ± 0.07	0.595
Body mass index (kg/m^2)[a]	27.40 ± 5.00	28.30 ± 4.70	0.311
Gender:[b]			0.711
- Female	78.30%	76.90%	
- Male	21.70%	23.10%	

Table 1. Characteristics of participants at the baseline. [a]Values expressed as Mean ± Standard Deviation; p-value of analysis of variance (independent samples t-test). [b]Values expressed as percentage (%); p-value of analysis of Chi-square.

	Baseline		24 weeks		Treatment (%)	Effect size	P
	Exercise	Control	Exercise	Control			
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean (95%CI)	Pη²	
Body composition							
Body mass index (kg/m²)	27.4 ± 5.0	28.3 ± 4.6	26.8 ± 5.1	28.0 ± 4.5	−1.1 (−2.6 to 0.4)	0.018	0.141
Physical Activity Enjoyment Scale (PACES)							
Very unpleasurable/Very pleasurable (1–7)	6.74 ± 0.57	6.82 ± 0.52	6.83 ± 0.48	6.66 ± 0.86	3.4 (−2.0 to 8.9)	0.013	0.217
No fun/A lot of fun (1–7)	6.78 ± 0.46	6.74 ± 0.59	6.83 ± 0.43	6.66 ± 0.71	1.3 (−3.6 to 6.2)	0.002	0.605
Very unpleasant/Very pleasant (1–7)	6.80 ± 0.45	6.83 ± 0.54	6.76 ± 0.56	6.82 ± 0.45	−0.8 (−5.2 to 3.5)	0.001	0.707
Not invigorating/Very invigorating (1–7)	6.76 ± 0.52	6.88 ± 0.45	6.72 ± 0.65	6.68 ± 0.65	2.4 (−2.6 to 7.3)	0.007	0.350
Not gratifying/Very gratifying (1–7)	6.78 ± 0.46	6.85 ± 0.48	6.78 ± 0.47	6.78 ± 0.52	0.7 (−3.6 to 5.0)	0.001	0.749
Not exhilarating/Very exhilarating (1–7)	6.78 ± 0.47	6.77 ± 0.64	6.85 ± 0.42	6.74 ± 0.57	0.3 (−5.5 to 6.1)	0.000	0.915
Not stimulating/Very stimulating (1–7)	6.76 ± 0.52	6.87 ± 0.46	6.76 ± 0.56	6.77 ± 0.56	1.5 (−2.9 to 6.0)	0.004	0.496
Not refreshing/very refreshing (1–7)	6.78 ± 0.46	6.68 ± 0.90	6.63 ± 0.90	6.52 ± 0.98	−2.6 (−11.3 to 6.1)	0.003	0.555
International Physical Activity Questionnaire (IPAQ)							
Vigorous activity (minutes/week)	160.0 ± 195.7	180.4 ± 163.6	155.3 ± 101.6	174.7 ± 144.9	0.2 (−29.7 to 27.7)	0.001	0.924
Moderate activity (minutes/week)	259.2 ± 177.4	233.7 ± 192.9	343.8 ± 263.6	255.1 ± 198.8	23.5 (−75.3 to 82.8)	0.065	0.103
Walking activity (minutes/week)	145.1 ± 166.9	209.1 ± 184.0	248.8 ± 305.6	216.1 ± 238.9	68.1 (−26.7 to 109.7)	0.148	**0.022**
Total physical activity (minutes/week)	564.3 ± 299.5	623.2 ± 369.8	747.9 ± 403.2	645.9 ± 396.1	28.9 (−80.9 to 89.4)	0.076	0.078
Total sedentary activity (minutes/week)	680.9 ± 507.4	879.6 ± 369.7	692.6 ± 503.6	760.3 ± 461.5	15.3 (−23.7 to 60.4)	0.010	0.388
SF-36 dimensions (scale 0–100)							
Physical function	77.1 ± 22.4	76.9 ± 21.7	79.8 ± 21.1	78.2 ± 20.9	1.8 (−7.8 to 16.9)	0.010	0.279
Role physical problems	93.9 ± 16.5	88.5 ± 18.5	87.5 ± 21.9	85.7 ± 19.2	−3.6 (−17.9 to 12.2)	0.001	0.710
Body pain	68.9 ± 22.2	65.0 ± 24.8	67.8 ± 25.2	67.8 ± 25.2	−5.9 (−20.9 to 14.6)	0.001	0.725
General health	59.7 ± 17.7	65.7 ± 17.0	62.2 ± 17.9	67.3 ± 17.0	1.8 (−6.2 to 18.5)	0.008	0.327
Vitality	72.9 ± 12.4	68.7 ± 15.8	66.1 ± 16.0	64.9 ± 13.9	−3.8 (−14.4 to 3.4)	0.012	0.223
Social function	94.8 ± 14.6	90.5 ± 17.2	93.2 ± 14.1	91.9 ± 16.2	−3.2 (−19.6 to 8.7)	0.005	0.453
Role emotional problems	97.8 ± 10.3	89.9 ± 18.5	91.8 ± 15.6	84.2 ± 20.1	12.5 (−17.5 to 27.5)	0.005	0.436
Mental health	66.1 ± 12.8	69.8 ± 15.7	67.8 ± 14.5	69.3 ± 13.8	3.3 (−8.3 to 11.6)	0.001	0.751

Table 2. Body composition, physical activity, and health-related quality of life measured at baseline and changes after the 24 weeks of physical training (EG $n = 46$; CG $n = 78$). P values of analysis of variance to compare differences between groups at 24 weeks. SF-36 = Short Form 36 Health Survey. Partial Eta Squared (Pη²) = η2 = 0.01 indicates a small effect; η2 = 0.06 indicates a medium effect; η2 = 0.14 indicates a large effect.

PACES questionnaire showed small differences between the baseline and the assessment after 24 weeks in both groups. No significant differences were observed in this variable. In addition, only the variable: Not invigorating/very invigorating (1–7) had a moderate ES (Pη²=0.007), while the others had a small ES.

IPAQ showed differences between the pre and post-test in both groups. However, only the Walking Activity (minutes/week) variable showed significant results ($p = 0.022$). In addition, the Moderate Activity (minutes/week) and Total Physical Activity (minutes/week) variables had a moderate ES (Pη²=0.065; Pη²=0.076, respectively), and the Walking Activity (minutes/week) variable had a large ES (Pη²=0.148).

Although statistical significance was observed in the Walking Activity domain, it is important to highlight the potential clinical relevance of this finding. An increase in walking time per week among older adults is strongly associated with improved functional mobility and a reduction in fall risk, particularly when walking exceeds 150 min per week. This threshold is often referenced in physical activity guidelines for older populations and has been linked to better balance, cardiorespiratory fitness, and muscle endurance. Therefore, the observed increase in walking minutes is not only statistically relevant but may also translate into meaningful improvements in independence and safety in daily living.

SF-36 dimensions questionnaire (scale 0–100) showed small differences between both moments of evaluation in both groups. There were no significant differences in this variable. In addition, all the variables had a small ES (Pη²<0.06).

Table 2. Body composition, physical activity, and health-related quality of life measured at baseline and changes after the 24 weeks of physical training (EG $n = 46$; CG $n = 78$).

Discussion

This randomized controlled trial evaluated the multidimensional effects of a 24-week sensorimotor training program on physical activity levels, body composition, and self-perceived quality of life in older adults.

Participants in the study shared similar characteristics regarding age, weight, and height. The BMI, calculated using the participants' weight and height, indicated that both male and female groups fell into the overweight category. Despite this, considering the body composition analysis after intervention, the BMI results of both groups decreased from the beginning until the following 24 weeks, with the EG showing a greater reduction.

Several studies indicate that women tend to participate in PE programs more frequently than men in older age groups[30,31]. According to our research, which involved 124 older adults, more than 70% of those engaging in the program were female. This trend aligns with broader findings in geriatric studies, where women consistently show greater engagement in organized exercise activities. This may be attributed to factors such as greater health consciousness, stronger social support networks, or a higher motivation to maintain functional independence compared to men[32,33]. These gender differences in participation rates are important to consider when designing exercise programs for older adults, as they suggest that tailored motivational strategies may be necessary to encourage both men and women to stay active and achieve similar health benefits[34].

In our study, the PACES questionnaire revealed minimal differences in overall enjoyment of PA between the CG and the EG over the 24-week sensorimotor training program. No statistically significant changes in general enjoyment were observed, suggesting that the intervention, while potentially beneficial in physical terms, did not significantly influence participants' affective experience of exercise. However, the item "Not invigorating/Very invigorating" did show a moderate effect size, indicating that some participants perceived the activity as more energizing, though this perception was not consistent across all aspects of enjoyment[17].

For instance, a study by Rejeski et al[35]. demonstrated that structured exercise programs led to significant improvements in the enjoyment of PA for some older adults, particularly when the program included social components and varied activities. Similarly, studies by Teixeira et al[36]. and Hammer et al[37]. found that while PA enjoyment can improve with consistent participation in exercise programs, the increase in enjoyment is often moderate and highly individualized.

From a motivational standpoint, these findings can be better understood through SDT, developed by Ryan and Deci[13]. SDT posits that intrinsic motivation—and by extension, enjoyment—is most likely to arise when three basic psychological needs are fulfilled: autonomy (feeling volitional and self-directed), competence (feeling effective), and relatedness (feeling socially connected). In our study, it is possible that the training structure did not fully support these needs. For example, limited choice in activities may have restricted autonomy, unclear or unacknowledged improvements could have diminished perceived competence, and lack of social interaction might have impeded relatedness. When these needs are unmet, intrinsic motivation—and therefore enjoyment—is less likely to emerge, even if physical outcomes improve.

Thus, while sensorimotor training may enhance physical capabilities such as balance and strength, this does not automatically lead to greater enjoyment of the activity. The modest changes in PACES scores observed in our study underscore the importance of developing interventions that not only target physical improvements but also actively promote the psychological and motivational conditions necessary for sustained PA engagement in older adults[38].

In our study, the IPAQ revealed differences in PA levels between the initial assessment and the assessment after 24 weeks for both the CG and the EG. Notably, the Walking Activity variable (minutes/week) showed statistically significant results, with a large ES, indicating that walking increased substantially in the experimental group following the sensorimotor training intervention. Additionally, the variables Moderate Activity (minutes/week) and Total Physical Activity (minutes/week) exhibited moderate ES, suggesting some improvements in overall PA, albeit to a lesser extent than walking. These findings align with other studies examining the impact of PA interventions on older adults, particularly concerning walking and moderate activity. Research by Tomioka et al. 39found that walking is often the most accessible and sustainable form of PA for older adults individuals, and interventions focusing on balance and strength, such as sensorimotor training, can enhance walking ability by improving postural control and lower limb strength. Similarly, studies by Pahor et al[40]. and Hung et al[41]. have highlighted that increasing walking activity is one of the most effective strategies for improving overall PA levels in older populations, particularly when combined with functional training exercises that target mobility and endurance.

The large ES for the Walking Activity variable in our study suggests that participants in the experimental group may have found walking easier or more enjoyable following the intervention. This supports findings from the literature, such as the study by Huang et al[42]., which observed that older adults who engaged in targeted exercise programs, including balance and coordination activities, demonstrated significant improvements in their capacity and willingness to walk longer distances. Walking is a low-impact, accessible activity that can significantly contribute to the total volume of PA, which may explain the notable increase in this variable in our study. In contrast, while Moderate PA and Total PA also showed improvements with moderate ES, these changes were less pronounced. This may reflect the natural preference among older adults for walking over more strenuous or structured forms of PA. Studies by Galle et al[43]. have similarly found that moderate-intensity activities, although beneficial, often require additional motivation or specific program elements, such as social support or tailored guidance, to achieve larger improvements. The significant increase in walking activity, supported by a large ES, highlights the potential of sensorimotor training to promote increased PA, particularly walking, in older adults. However, moderate-intensity and overall, PA levels may require further targeted strategies to achieve similar significant improvements. These findings underscore the importance of designing interventions that focus on functional capacity and practical, enjoyable activities like walking that older adults can easily incorporate into their daily lives.

In our study, the SF-36 dimensions questionnaire, which evaluates various aspects of health-related quality of life on a scale from 0 to 100, showed small differences between the baseline assessment and the 24-week follow-up in both the CG and the EG. There were no significant differences between the groups in any SF-36 variables, and all variables had a small ES, indicating that the sensorimotor training intervention had a limited impact on self-reported quality of life in this population over the 24 weeks. These results are consistent with findings from other studies investigating PA interventions´ on the QoL in older adults. For example, Brown et al[44]. found that while exercise interventions can improve physical health markers, changes in self-reported QoL as measured by the HRQoL are often modest or not statistically significant in short-term studies. One possible explanation for the limited effects observed is a ceiling effect, as baseline SF-36 scores were already moderate to high. This can restrict the measurable room for improvement, especially in relatively healthy and functionally independent older adults. A systematic review by Rejeski and Mihalko[45]similarly concluded that physical gains from exercise do not always correspond to perceived improvements in QoL—particularly when the intervention period is short or when participants already report satisfactory levels of well-being at baseline. Another study by Stewart et al[46]. found that while PA can enhance physical functioning and reduce disability, significant changes in subjective QoL—especially in dimensions related to emotional well-being and mental health—often emerge only over longer durations.

This delayed impact may partly explain the small differences observed in our study, as 24 weeks may not have been sufficient for meaningful perceived changes in QoL to manifest. Furthermore, research by Zhang et al[47]. indicates that psychological mediators such as self-efficacy, perceived autonomy, and social support strongly influence how older adults interpret improvements in their QoL. Since our study did not directly address or enhance these psychological dimensions, this may have further limited the perceived impact of the intervention on QoL outcomes.

The small ES and lack of significant differences in SF-36 dimensions in our study align with existing literature, which suggests that while PA improves physical health, its effect on self-reported QoL—especially in short-term programs—is often limited unless paired with strategies that also target emotional and psychosocial factors. Several limitations should be acknowledged in this study. First, the sample population was predominantly female (over 70%), which, while consistent with trends in geriatric exercise research, may limit the generalizability of the findings to older male adults. Future research should strive for a more balanced gender representation by employing targeted recruitment strategies aimed at engaging older men—such as involving male-focused community groups or emphasizing exercise components that may be more appealing to this demographic. Additionally, while improvements in physical activity levels and body composition were observed, the enjoyment of physical activity, as measured by PACES, showed only modest changes. This suggests that the program may not have fully addressed motivational factors critical for sustained engagement. Future interventions should consider incorporating a wider variety of exercise formats, opportunities for social interaction, and greater personalization to align with individual preferences and enhance enjoyment. Furthermore, designing interventions aligned with Self-Determination Theory (SDT) may enhance psychosocial engagement. Incorporating structured strategies that support autonomy (e.g., participant-led goal setting), competence (e.g., progressive skill challenges with feedback), and relatedness (e.g., peer-based group activities) can foster greater intrinsic motivation, potentially improving adherence and long-term outcomes.

Secondly, the QoL, as measured by the SF-36, showed only small changes, with no significant differences between the experimental and control groups. This may be due to a ceiling effect or the relatively short duration of the intervention. Short-term programs like the 24-week duration used in this study may not be sufficient to elicit measurable improvements in self-reported QoL, particularly in areas related to emotional well-being and mental health. Extending the length of interventions and incorporating psychological and social support elements may yield more substantial and lasting improvements.

Thirdly, the study lacked a post-intervention follow-up, which limits the ability to assess the sustainability of observed benefits over time. Without follow-up data, it is unclear whether improvements in physical activity levels, body composition, or functional ability were maintained beyond the active intervention period. Follow-Up Assessments in Future Studies: Long-term data would strengthen conclusions about behavior change and sustained QoL impact. Longitudinal follow-ups are recommended to better understand long-term adherence and the lasting impact of sensorimotor training on health and QoL.

Fourthly, the study lacked a post-intervention follow-up, limiting the ability to assess the sustainability of observed benefits over time. Without longitudinal data, it remains unclear whether gains in physical activity levels, body composition, or functional capacity were maintained after the end of the intervention. Future studies should incorporate follow-up assessments to evaluate long-term adherence and the durability of effects associated with sensorimotor training.

Fifthly, the study may be affected by self-selection bias, as individuals who chose to participate were likely more health-conscious or motivated than the general older adult population. This could lead to an overestimation of intervention effects. Strategies to recruit a more representative and diverse sample—particularly individuals who are less active or less engaged in health behaviors—should be prioritized in future research. Additionally, although participants shared similar baseline characteristics (age, weight, height), this homogeneity may limit generalizability. Broader inclusion criteria and recruitment across diverse settings (urban vs. rural, varied socioeconomic backgrounds) are recommended to better reflect the heterogeneity of the older population.

Sixthly, and importantly, adherence and dropout data were not collected or reported, limiting insight into the feasibility and acceptability of the intervention. Understanding session attendance, reasons for dropout, and barriers to participation is essential for evaluating real-world applicability. Future trials should monitor adherence systematically and report these data transparently.

Seventhly, no mention was made of assessor blinding in the study protocol, which could introduce bias in outcome evaluations, particularly when subjective measures are used. Although the trainers were experienced and implemented the intervention under supervision, failure to ensure or report assessor blinding represents a methodological limitation. Future studies should employ independent, blinded assessors to reduce the risk of detection bias in randomized designs.

Finally, several outcomes—such as physical activity levels, enjoyment, and quality of life—relied exclusively on self-reported instruments, which may be influenced by recall bias, social desirability, or cognitive limitations. The absence of screening for literacy or cognitive status means that some participants may have had difficulty understanding or accurately completing the questionnaires. Incorporating objective assessments and pre-screening for cognitive competence would help improve the reliability of self-reported data in older adult populations. In sum, while the study provides valuable insights into the effects of sensorimotor training in older adults, these limitations highlight important areas for improvement in future research to ensure methodological rigor, broader applicability, and more robust conclusions.

Conclusions

The findings of this study reveal several notable observations regarding the impact of a 24-week sensorimotor training program on body composition, PA levels, and quality of life among older adults. While participants across the EG and CG were similar in terms of age, weight, and height, both groups exhibited a decrease in BMI over the study period, with the EG showing a greater reduction, albeit not statistically significant.

The PA levels, assessed through the IPAQ, demonstrated notable improvements, particularly in walking activity, which showed significant results and a large ES. Moderate activity and total physical activity also showed moderate ES, indicating the program's potential to promote more active lifestyles in older adults.

Regarding enjoyment of physical activity, as measured by PACES, only small changes were observed, with no significant differences. However, the "Not invigorating/Very invigorating" variable showed a moderate ES, suggesting some participants experienced increased perceived enjoyment during exercise.

Finally, the quality of life, as evaluated by the SF-36, showed slight improvements in both groups, though these changes were not statistically significant, and ES remained small.

In summary, the study results indicate that both groups experienced improvements in body composition, PA, and QoL after the 24-week training period. However, the EG demonstrated improvements than the CG, although statistical significance was not reached for all outcomes, the observed trends—particularly in walking activity and BMI—suggest clinically meaningful benefits of sensorimotor training in this population.

Practical applications:

- Implement evidence-based sensorimotor training programs to improve mobility, balance, and functional independence in older adults. These programs can reduce fall risk, enhance muscular coordination, and contribute to greater autonomy in daily living tasks, thereby supporting healthy aging and reducing healthcare burdens.
- Promote walking as a primary, accessible form of physical activity, especially for older populations. Walking is safe, low-cost, and adaptable to individual fitness levels. It has been shown to improve cardiovascular health, cognitive function, mood, and quality of life, making it an ideal foundation for PA interventions in aging populations.
- Tailor physical activity interventions to accommodate individual preferences, physical capabilities, and motivational profiles. By fostering a sense of autonomy, competence, and relatedness—key principles from SDT—programs can enhance enjoyment and long-term adherence to PA routines.
- Use physical activity assessments (e.g., SF-36, PACES, IPAQ-SF) to evaluate participants' baseline fitness levels, health perceptions, and enjoyment of exercise. These tools help guide personalized adjustments to maximize effectiveness and satisfaction.
- Understand the multifaceted impact of PA on aging, not only in terms of physical health (e.g., strength, endurance, body composition) but also in improving mental health, emotional well-being, and over-all quality of life. Interventions should aim for holistic outcomes by integrating physical, psycho-logical, and social dimensions.
- Design community-based, socially engaging programs that foster interaction, routine, and purpose among older adults. Such environments have been shown to improve exercise adherence and in-crease the likelihood of sustained benefits.

Data availability

The data that support the findings of this study are available from the first author (carolina.cabo@uevora.pt) upon reasonable request.

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Conceptualization, C.A.C.; methodology, C.A.C; and P.T.C.; software, C.A.C; validation, O.F; and M.C.E; formal analysis, C.A.C., and P.T.C.; investigation, J.A.P., and M.C.E; data curation, O.F., and J.A.P; writing—original draft preparation, C.A.C; writing—review and editing; O.F; M.C.E.; P.T.C., and J.A.P; visualization, O.F., and

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The study was approved by the Ethics Committee of the University of Évora (approval number: 21040).

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

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