Suspension training HIIT improves gait speed, strength and quality of life in older adults

Abstract

This study aimed to evaluate the effects of a twelve-week high-intensity interval exercise (HIIT) training program involving suspension exercises (TRX) on the muscle strength, body composition, gait speed, and quality of life of older adults. A total of **82** older adults were randomly assigned to three groups: a HIIT group (n = 28), a continuous intensity training group (MIIT group, n = 27), or a control group (CG, n = 27). **Compared to MIIT and CG, participants of the HIIT group showed significant post-intervention improvements in BMI ($p = .002$ and $p < .001$, respectively) and gait speed ($p < .001$ for both). Handgrip strength increase was also observed after HIIT ($p = .002$), but no differences were observed with MIIT and CG. Compared with MIIT and control groups, HIIT showed improvements in the SF-36 domains: general health ($p < .001$ for both) health changes ($p < .001$ for both), vitality ($p = .002$ and $p = .001$ respectively) and physical functioning ($p = .036$ and $p < .001$ respectively). Our results suggest that a HIIT training program with TRX have benefits in BMI, handgrip strength, gait speed, and quality of life in older adults**.

KEYWORDS

Older adults – HIIT – TRX – Handgrip Strength – Gait Speed – Quality of Life

Introduction

In an increasingly aging population, the number of people over 65 is rising. In 2010 26.2% of the Spanish population was older adults, but in 2016 it was increased to 85.8% [12]. This amount is expected to increase over the fifth decade of the 21st century, with numbers worldwide reaching two billion people over 60 years old [26]. Aging is generally associated with a progressive deterioration of physical function and psychological health [31,24], as well as with a constant increase in the risk of disability, dependence [30], and comorbidity [40].

Aging process involves a reduction in the number and size of motor units and type-2 fibers, with a loss in muscle size of about 1% per year for people over 50 years of age [36]. These factors affect physical condition of older adults and induce the loss of muscle strength, which directly influences their degree of physical independence and health [52]. In this sense, grip strength and muscle strength have been shown to be more important than muscle mass in estimating mortality risk [48]. Previous studies have shown that a deficit in grip strength is associated with an increased risk of malnutrition and mental and physical deterioration **[56]**, since these factors are relevant for the autonomy and quality of life of older adults [19,45].

Due to age, older people reduce their physical activity in a degree increasing dependency. This can be prevented or treated by improving strength and several parameters of walking and balance through the practice of **different types of exercises such as Pilates or proprioception training program** [23,35]. In addition, physical exercise improves mobility, functional capacity, and, therefore, personal autonomy, [62]. With regard to body composition, the effects of exercising are conditioned by various aspects such as the characteristics of each person and the type of exercise they perform [27].

High-intensity interval training (HIIT) has attracted attention in recent years as an exercise option for both young and adult population. This type of exercise is characterized by brief and intermittent sessions of high-intensity activity which alternated with periods

of rest or low intensity. The number of studies looking into this type of training in the elderly population has increased lately [28,29]. It has recently been shown that postural control and risk of falls can improve after HIIT compared to the effects of a continuous exercise program in healthy and untrained young people **[25],** and also in patients with some type of pathology [6]. In the elderly, some randomized trials have studied the effects on cardiovascular and anthropometric outcomes after HIIT interventions [41,53].

Recent studies have described the benefits of a HIIT program on physical fitness and quality of life in healthy and diseased populations [1,43] Nevertheless a systematic review and meta-analysis published in 2018 concluded that there were no evidence supporting important differences in health-related quality of life in heart failure patients with reduced ejection [18]. Benefits in physical functioning have been also described after HIIT training in healthy older adults [16].

Suspension training has become increasingly popular as a training tool. [11]. In this activity the intensity of the exercise can be varied depending on the position of the body and the effects of gravity, with body weight acting as resistance. Suspension training can be individually adapted for each older adult according to its precondition, demands and preference [15], and it has been shown to have beneficial effects on muscle activation and balance [2,7]. To the best of our knowledge, this is the first randomized controlled trial to use HIIT with suspension training exercises in older adults.

In the light of the above considerations, the aim of the present study was to evaluate the effects of a twelve-week HIIT training program involving suspension exercises (TRX) on muscle strength, body composition, gait speed, and quality of life of older adults over 60 years, as well as to establish a comparison with a moderate intensity interval training (MIIT). Given the information mentioned above, we hypothesized that HIIT with a suspension exercise system (TRX) can be an efficient exercise choice and an effective training method for older adults.

Method

Design and Participants

This is a randomized controlled clinical trial (RCT) which is part of a research project that analyzed the effects of two different TRX training programs (HIIT and MIIT) on different physical and psychological health indicators in community-dwelling older adults, registered at clinicaltrials.gov as NCT03404830 (https://clinicaltrials.gov/ct2/show/NCT03404830), so there may be some overlap with respect to participants and general methodology. The recruitment of participants was carried out through the sports service of the Town Hall of Xxxxxxx (Xxxxxx, Xxxxx) **and participants were contacted using municipal records (e-mail, and telephone calls), local media and social networks**. From a total of 90 persons who were initially contacted, and **after medical screening by a certified physician**, 82 (**68.23 ± 2.97 years, 75.61% women**) met the eligibility criteria and accepted to be enrolled.

In order to participate in the study, participants were required to be over 60 years old and able to understand the instructions, programs, and protocols of this project. An informed written consent was obtained from each participant before enrollment. Exclusion criteria were conditions that contraindicated the performance of physical tests, diseases that could alter balance and functional activity (such as auditory or vestibular alterations), psychiatric or neurological disorders, **systemic diseases (i.e. diabetes mellitus, cancer or heart disease or skeletal conditions),** or were already included in other training program. **This study was approved by the local Human Ethics Committee (DIC.17/5.TES University of Jaen), according with the Declaration of Helsinki, good clinical practices, and applicable laws and regulations, and in accordance with the Ethical Standards in Sport and Exercise Science Research [20]. Informed consent was obtained from all participants, and the rights of the participants were protected.**

Procedures

Measurements were recorded before training (pre-intervention) and just after the intervention period (post-intervention). Participants included in the study were randomly

assigned to a high-intensity interval training group (HIIT group), to a moderate intensity interval training (MIIT group), or to a control group (CG) in a 1:1:1 ratio using a computer-generated table of numbers, **each one of which had been previously assigned to one of the three groups (28 numbers per group).** Assignments were kept at a locked location in a sealed, opaque envelope, to be later opened by an independent part not involved in subject selection, evaluation of results, or treatment. A total of 28 people were assigned to the HIIT group, 27 to the MIIT group and 27 to the CG. These numbers were later reduced to 26 for the HIIT group (**68.23 ± 2.97 years, 92.3% women**), 24 for the MIIT group (**68.75 ± 5.98 years, 70.8% women**), and 23 for the CG (**68.52 ± 6.33 years, 65.2% women**) for various reasons, showed in figure 1. **Participants assigned to the HIIT and MIIT groups participated in a 12-week suspension training program,** while those assigned to the CG maintained their daily lifestyle and received a series of guidelines to encourage physical activity, but were instructed to refrain from participating in any systematized exercise activity

Anthropometry

All anthropometric data were collected by a physician specifically trained according to a standardized protocol [32]. Height was r**ecor**ded to the nearest **0.01** cm with a stadiometer. The participants wore light clothing and were barefoot when measured. Relaxed waist, hip, and calf circumferences were taken and rounded to the nearest 0.1 cm using a non-stretchable measuring tape. Body mass index (BMI) was calculated as body mass in kilograms divided by the square of height in meters.

Body Composition

Bioelectrical impedance analysis was used to measure body composition. Skeletal muscle mass (SMM) and percentage of body fat (PBF) were examined using the InBody 720 (Biospace Co., Ltd.; Seoul, Korea) bioelectrical impedance analyzer, with an operating frequency of 50

kHz at 800 μA. Participants stood upright with their arms abducted apart from their trunk and legs slightly spread.

Handgrip strength

Muscle strength, measured by an analogue handgrip dynamometer (TKK 5001, Grip-A, Takei, Tokyo, Japan) with a grip span of 4.5 cm, was employed for muscle strength **[3].** Participants were asked to apply their maximum grip strength three times with both left and right hand, with 30s resting intervals between measurements. The maximal measured effort was regarded as their grip strength [31].

Gait speed

The Timed Up-and-Go test (TUG) is a simple, valid, and reliable method to assess functional mobility and balance [49], which has already been used in elderly women [51]. It is based on everyday activities and requires standing from a chair, walking three meters, turning around, and sitting down again [48]. The time required by the subject to complete this task is recorded. In addition, the time scored in the TUG test was converted to an estimate of gait speed using the formula **[6 / (TUG time) * 1.62]** [31].

Health-related quality of life

The generic 36-item Short-Form Health Survey (SF-36) is a valid and reliable instrument that is widely used to measure generic health-related quality of life [59]. It consists of nine scales or domains: physical functioning (ten items), role-physical (four items), bodily pain (two items), general health (five items), vitality (four items), social functioning (two items), role-emotional (three items), and mental health (five items). The SF-36 also provides two summary measures: a physical component summary (PCS) and a mental component summary (MCS). Total score ranges from 0 to 100, where 0 represents the worse quality of life and 100 represents the best quality of life. The Spanish version of the SF-36 was translated and validated in the

Spanish population by Alonso et al. [4], **and its reliability has been demonstrated in several age ranges, including that of the present study [59].**

Suspension exercise training program

The suspension training tool consists of two straps and two handles, which require continuous grip. The exercise regimen presented here was developed using the TRX (TRX; Fitness Anywhere LLC, San Francisco, California, USA). **Before the intervention, participants of the HIIT and MIIT groups performed a 4-week familiarization period (2 session/week with video demonstrations and 6 repetition practice trial). The main work was performed in squat position and strap was adjusted at mid length. Participants started in standing position, looking at the anchor point, grasping the handles with the whole hand, and with elbows bent at 90º. Participants squatted down to a knee angle of approximately 90°, and then extended the knee in one continuous movement to reach the starting position.**

Participants assigned to the MIIT group and the HIIT group received two sessions per week of TRX for twelve weeks. **In the HIIT group, each session was divided into three periods: warm-up (10 minutes), main squat activity with suspension system divided into four four-minute intervals at an intensity of 90-95% of the maximum HR followed by active rest intervals In the MIIT group, participants followed the same protocol that HIIT group, but intensities were lower: 70% and 50% of the maximum HR for the main squat activity and the active rest intervals respectively. In order to assess maximum HR, we followed instructions provided by Elligsen et al. [13]. The intensity of exercise was controlled through a Polar V800 (Polar Electro, Oy, Kempele, Finland), thus ensuring that their heart rate (HR) was kept in the range determined according to each participant's age and assigned group. The intensity was individually adjusted to HR at moderate or vigorous efforts and maintained constant during the intervention. The training sessions were**

conducted and supervised by a well-trained sports instructor. Two physical therapists supporting each class ensured that instructors were doing correctly. HIIT sessions took place on Tuesday and Thursday, and MIIT sessions took place on Monday and Wednesday, always at the same time (10:00-11:00 a.m.), meaning this a 24h-rest between sessions. Participants were excluded if more than five sessions were lost during the twelve-week intervention. During the intervention, injuries and other effects reported by the participants were observed.

Statistical analyses

Data were analyzed with the statistical program SPSS v.21.0 for Windows (SPSS Inc., Chicago, USA) and the level of statistical significance stood at $p < .05$. Descriptive statistics are shown as means and standard deviations. The chi-square test was used to compare sociodemographic variables between groups. The analysis of variance of a single factor was used to verify the non-existence of statistically significant differences in the pre-intervention measures. When pre-test differences existed a univariate analysis of variance was used, considering post-intervention measures as a dependent variable and pre-intervention measures as a covariate. Likewise, the 3x2 mixed variance analysis was used, considering as the inter-group variable the type of intervention received (group to which the participant was assigned) and as the intra-subject variable the time of measurement (pre- and post-intervention) for each of the dependent variables (anthropometry, bioimpedance, handgrip strength, gait speed, and quality of life). The analysis of possible interactions was carried out by analysis of variance and *t* tests for repeated measures. Finally, the effect size of the differences between values was interpreted using Cohen's d statistic [9]. An effect size <0.2 reflects a negligible difference, ≥ 0.2 but ≤ 0.5 a small difference, ≥ 0.5 but ≤ 0.8 a moderate difference, and ≥ 0.8 a large difference.

Results

Subjects showed high adherence to the exercise training programs, participating in at least 83,33% of the sessions. As showed in Figure 1, a total of 9 participants were lost in the follow-up, 2 (HIIT group), 3 (MIIT group) and 4 (CG).

Anthropometry

There were statistically significant differences between groups concerning hip circumference measurements, $F(2, 70) = 11.17$, $p < .001$; and body mass index, $F(2, 70) = 4.19$, $p = .019$, prior to the intervention. **Therefore, these two variables were employed as covariates in subsequent analysis. Pre- and post-intervention values are presented in table 1.** After the intervention, only BMI showed significant differences between groups, $t(25) = 5.68$, $P < .001$. More specifically, post-intervention values were lower in the HIIT group compared with the MIIT group, $t(48) = -3.27$, $p = .002$; and CG, $t(47) = -5.86$, $p < .001$. Additionally, the values observed in the MIIT group were lower than those of the CG, $t(45) = -2.70$, $p = .01$. No significant differences were observed for the other anthropometric variables.

Body composition

As for body composition analysis, pre- and post-intervention values are showed in table 1. The analysis did not reveal the existence of main effects or statistically significant interactions for the dependent variables body weight, SMM, and PBF.

Handgrip strength

When the values reached in the dynamometry test were the dependent variable, a main effect of the independent variable was obtained, $F(1, 70) = 6.42$, $p = .01$, $\eta 2 = .08$, as a statistically significant interaction of group x measurement time, $F(2, 70) = 4.48$, $p = .01$, $\eta 2 = .11$. Group, $F(2, 70) = .14$, $p = .872$, did not appear to be statistically significant. The detailed analysis of the interaction revealed the existence of statistically significant differences between both

measurement times in the HIIT group, t (25) = -3.39, p = .002, d = .41. No other comparison reached statistical significance **(Fig. 2).**

Gait speed

When the dependent variable considered was the gait speed evaluated by the TUG test, a statistically significant main effect of the group variables was observed, F (2, 70) = 65.45, p = .006, η2 = .14; as well as for time of measurement, F (1, 70) = 12.79, p = .001. In turn, the interaction of group x time was statistically significant, F (2, 70) = 9.52, p <.001, η2 = .21. The detailed analysis of the interaction revealed the existence of statistically significant differences between both measurement times for the HIIT group, t (25) = -4.81, p = .002, d = -1.51. Also, in post-intervention measures gait speed differed significantly between the participants in groups HIIT and MIIT, t (48) = 4.72, p <.001, d = 1.23, as well as between groups HIIT and control, t (48) = 4.64, p <.001, d = 1.27 (Fig.3).

Health-related quality of life

Given the initial differences between groups, as well as their potential influence on the perception of quality of life associated with health, BMI was introduced as a covariate in the different analyzes, although, it was only statistically significant for the dependent variable PCS. In the analysis of the SF-36 dimensions (Table 2), statistically significant differences after the intervention were observed in the HIIT group regarding general health: t (25) = -3.02, p = .006, d = .64; health changes: t (25) = -2.89, p = .009, d = .76; and vitality: t (25) = -3.23, p = .003, d = .66. Participants of the HIIT group showed statistically higher values after the intervention compared to CG in general health: t (47) = 4.05, p <.001, d = 1.15; health changes: t (47) = 4.20, p <.001, d = 1.19 and vitality: t (47) = 3.49, p = .001, d = 1.00. Finally, statistical differences with MIIT were also found in the HIIT group regarding general health: t (48) = 5.16, p <.001, d = 1.47; health changes: t (48) = 3.84, p <.001, d = 1.08 and vitality: t (48) = 3.33, p = .002, d = .94.

Due to the existence of statistically significant differences between groups in physical functioning prior to the intervention, a unifactorial ANOVA was performed using baseline physical functioning score as covariate. The dependent variable was the post-intervention values in physical functioning. We found a statistically significant main effect of the covariate, $F(1,68) = 8.04$, $p = .006$, as well as of the independent variable group, $F(2, 68) = 7.64$, $p = .001$, $\eta 2 = .18$. Significant differences were observed between CG and both MIIT group: $t(45) = 2.14$, $p = .032$, $d = .59$; and HIIT group: $t(47) = 4.54$, $p < .001$, $d = 1.13$. Statistically differences were also observed between HIIT and MIIT: $t(48) = 2.15$, $p = .036$, $d = .57$.

Finally, as for the SF-36 summary component scores (Table 2), the analysis of MCS showed a significant effect for BMI covariate, $F(1, 69) = 4.21$, $p = .044$, $\eta 2 = .06$, as well as a significant main effect for the variable time, $F(1, 69) = 5.19$, $p = .026$, $\eta 2 = .07$. In PCS analysis, only a significant effect for group was observed, $F(2, 69) = 5.68$, $p = .005$, $\eta 2 = .14$. No other main effect or statistically significant interaction was obtained for the rest of the SF-36 dimensions (Table 2).

Discussion

The results of the present study highlight the benefits of a HIIT training program with suspension training exercise program (TRX) in handgrip strength, gait speed, BMI and health-related quality of life in older adults over 60 years. No significant changes were found in body composition.

There are not many studies about the effects of suspension training, but as mentioned in the introduction, there is a recent increase of studies that analyzes the effects of HIIT in older population. Regarding body composition and anthropometric parameters, a study by Garcia Pinillos et al. [16] found significant differences in body composition for older people (-2.15% body mass, -4.20% fat mass, +6.23% muscle mass) **after a 12-week low-volume HIIT-based concurrent training programme**. **However** Ramirez et al. [51], in a study with the same intensity of HIIT and the same duration of intervention did not find significant improvements in waist and hip circumference in adults with metabolic syndrome and Bartlett et al. [5], in a recent study involving elderly people over 64 years, described no significant improvement in fat percentage after ten weeks of HIIT intervention. **On the other hand, very few studies have analyzed the effects of suspension training, especially in older adults, and thus a recent study performed on older women (aged 66.1 ± 4.7 years) showed that a 12-week suspension exercise training program led to significant decrease in percentage of fat mass, as well as in triceps, biceps and subscapular skinfolds [8]. The results of the present study indicated that a HIIT with suspension training had significant improvements in BMI, while in SMM and PBF decreased but these differences did not reach statistical significance.**

Most of the studies on suspension training have focused on muscle activation [21,37]. In this respect, a recent systematic review concluded that suspension training increases muscle activation compared with traditional exercises, except for inverted row exercises, where no differences were observed for certain muscles such as biceps brachii, posterior

deltoid and middle trapezius [2]. Handgrip strength has been strongly linked to lower limb muscle power, torsion and extension of the knee, and the transverse muscles of the calf [40]. Max et al. in a study carried out in Sanda athletes concluded that compared with traditional core strength training methods, suspension training can improve the explosive power of trunk extension and flexion muscles [33]. In our study, the HIIT group achieved significant improvements in handgrip strength after the intervention. Our results are in accordance with those found by Campa et al., [8] and we agree with them when they suggest that this may be considered to be a consequence of constantly having to grab the handles of the suspension training system. Similar increases in grip strength after a HIIT training period were highlighted by Onambelé et al. [47], when comparing their results with those of a control group and by García-Pinillos et al. [16], which showed a significant increase in grip strength after HIIT. In addition, Nemoto et al. [42] reported an increase in **lower body** strength, increasing knee extension in the HIIT group by 13% in comparison with the MIIT and control groups. All these studies were performed in populations over 60 years of age.

Adult population experiences a decrease in muscle mass, which is associated with low levels of muscle strength and poor physical performance [10]. **Emara et al. described that, compared to treadmill-training, a three-month body-weight suspension training was more effective in improving walking and locomotor capabilities in children with spastic diplegia [14], and Gaedtke et al. [15] found, after 12 weeks of TRX-suspension training in older adults, self-rated improvements in strength, gait, and balance**. In our study, we used gait speed assessed with the TUG test to determine physical performance, and we observed a post-treatment increase in the HIIT group (**18.03%)**, with a large effect size (d = 1.51). This is in accordance with those of other studies involving HIIT treatments in both healthy and chronic stroke survivors older adults [16,47].

Regarding the practical applications of the strength and gait speed results, one of the concerns most commonly cited in previous research is their link to the risk of falling. It has been shown that common gait deficits observed in older adults, such as a greater stride width [63] and stride-to-stride variability are independent predictors of falls [31], and gait speed of people who do not experience falls is significantly higher than that of those who do [24,61,57,55,58]. With respect to handgrip strength data, Moreira et al. [38] concluded that the probability of falling was lower among those with greater grip strength. In addition, this study showed that muscle strength, balance deficiencies, fear of falling, and a previous history of falls have been described as the main independent predictors of the risk of future falls [40].

Finally, as for health-related quality of life, A recent study performed in healthy inactive adults (31.7 ± 2.6 years) reported that a HIIT with low and moderate training frequency (two and three times per week) showed significant improvements in the SF-36 physical health component, but only moderate-intensity training improved the mental component of quality of life [54]. In the present study, we found significant benefits after HIIT compared to both MIIT and CG with regards to the SF-36 domains general health, health changes, vitality and physical functioning, with large size effects (with Cohen's d values ranging from .94 to 1.47) and physical functioning domain with compared to the MIIT and CG group (Cohen's d values of 1.13 and .57 respectively). However any significant improvement in the mental component of quality of life was observed after both HIIT and MIIT programs. In a study by Globas et al. [17] demonstrated improvements in mental health after a treadmill high-intensity training program for an chronic stroke survivors > 60 years, measured through a more concise questionnaire (SF-12). In addition, the study by Knowles et al. [29] with the two-way repeated measures ANOVA revealed a significant main effect for group and an interaction between group and measurement phase in the "physical functioning" and "general health" constructs, of the SF-36 (physical function and general

health) after a cycle ergometer low-volume HIIT intervention in sedentary and active older adults, which appeared to cause these improvements in healthy sedentary ageing male aged 55 years and older.

These findings could reinforce the theory that high-intensity is an appropriate training system for the elderly population. There are some limitations in this study that must be addressed: the participants were healthy older adults, and the results may not be generalized to older adults with clinical conditions. We were not able to monitor physical activity levels outside the study setting nor to track dietary intake, although individuals were asked to maintain their usual lifestyle habits.

Conclusions

A HIIT program with suspension exercises was effective to improve gait velocity, thus improving lower-body performance, grip strength and subjective perception of health-related quality of life in adults aged 60 years and over. A significant decrease in BMI was also found after HIIT with suspension exercises. Therefore, suspension exercise training could be a very valuable method to achieve improvements in the health of the elderly. In addition, this tool is economical and portable. Our findings may be useful for exercise physiologists, especially those working with older people, wishing to implement specific training plans for the geriatric population.

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