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The effect of regular walking and its combination with manual therapy or resistance exercise on the 6-minute walking distance in healthy elderly

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SUMMARY/ABSTRACT

Starting point: The global aging population is growing rapidly, and preventive exercise programs are essential for maintaining seniors' overall health. Walking-based programs, resistance exercises, and manual therapy each offer individual benefits, but there is limited research on the combined effects of these interventions. Investigating how these interventions work together could lead to more effective strategies for enhancing health outcomes in older adults.
Group: This study involved 88 non-sedentary, non-smoking seniors with no specific comorbid conditions.
Methods: All participants were randomly assigned to one of four groups: walking group, walking + manual therapy group, walking + resistance exercise group or control group. There were two assessments performed, pre-intervention and post-intervention determining 6-minutes walking distance (6MWD).
Results: The walking group showed a significant decrease in 6MWD, while the walking + manual therapy group exhibited a significant increase in 6MWD. Neither the walking + resistance exercise group nor the control group showed any change in 6MWD over time.
Conclusions: Our results suggest that combining walking with manual therapy may be an effective way to enhance cardiopulmonary fitness in healthy elderly individuals. According to available literature, regular walking alone, or in combination with resistance exercise, can positively impact seniors' health when appropriately tailored to their fitness levels.

KEYWORDS

elderly adults, walking, manual therapy, resistance exercise, cardiorespiratory fitness, 6-minute walk test, 6-minute walk distance

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1 INTRODUCTION

The world population is aging at a fast rate. The percentage of global population aged 65 and above is expected to rise from 10% in 2022 to 16% in 2050 [1, 2]. It is necessary to respond to this challenge in a timely manner [3]. Engaging in a regular physical activity has been associated with many health benefits in elderly people [4]. Regular physical activity can reduce the impact of involutional changes as well as it can slow down the onset of these changes [5]. Regular physical activity is also linked to enhancements in mental health, emotional, psychological, and social well-being, as well as improved cognitive function [4]. Independence in seniors when performing activities of daily living is a serious challenge worldwide [6]. Research suggests that exercise can delay dependence in older adults and enhance physical abilities, such as sit-to-stand transitions, balance maintenance, and mobility [7, 8]. Another study reports that exercise training interventions effectively increase walking speed, improve balance, and enhance performance in activities of daily living (ADLs) among the elderly [9]. Various studies identified the 6-minute walk test as a tool providing valuable insights into the performance capacity for ADLs in adults [10, 11] as it reflects endurance and overall physical performance [12]. The self-paced 6-minute walk test evaluates functional capacity at the submaximal level, allowing individuals to select their own exercise intensity and take breaks as needed [12]. Since most ADLs are performed at this submaximal effort, the 6-minute walk distance (6MWD) provides an accurate representation of functional exercise capacity in real-life situations [13, 14] as it does not measure physical performance at maximal exertion level, therefore its relevance to ADLs makes it a valuable tool for assessing physical performance in adults [14].

In our study, we aimed to investigate the effect of regular walking and its combination with manual therapy or resistance exercise on functional capacity (6MWD) in healthy seniors. Previous studies have already proven the beneficial effect of regular walking on various health outcomes in elderly people such as cardiovascular health [15], mental health [16], musculoskeletal health [17], metabolic health [18] and many more. We believe that regular walking has the potential to improve cardiorespiratory endurance by enhancing oxygen utilization and increasing walking efficiency, which could lead to an increase in the 6MWD [19]. Many studies have also examined the beneficial effect of resistance exercise in elderly adults on musculoskeletal function [20], osteoporosis [17], balance [21], metabolic outcomes [18] cardiovascular health [22] and others. Research suggests that strengthening the core muscles and thoracic muscles by engaging in the resistance exercise can help in further stabilization of the torso, enhancing gait efficiency and possibly the walking distance in older adults [7]. Manual therapy also provides multiple health benefits for seniors from pain reduction [23] to posture correction [24]. We hypothesize that manual therapy administered on thoracic and cervical region can improve thoracic joints mobility and respiratory mechanics leading to more effective oxygen exchange, improving the endurance tasks like the 6MWT. Additionally, better posture from thoracic manual therapy can positively influence gait biomechanics as well.

While walking is a fundamental aerobic exercise that enhances overall health, combining it with resistance training and manual therapy focused on the thoracic region and cervical region may yield greater benefits. These interventions can improve muscle strength, thoracic mobility, and respiratory efficiency, potentially boosting 6MWT performance in healthy seniors. This study explores the synergistic effects of these modalities on walking endurance and physical function.

This study was conducted at Faculty of Physical Education and Sports, Charles University in Prague, Czech Republic from December 2022 to March 2023. The study was approved by UK FTVS Ethics Committee (266/2022).

2 GROUP AND METHODS

2.1 SAMPLE CHARACTERISTICS

A total of 88 participants who met the inclusion criteria and successfully finished the training protocol were included in the study. The participants were enrolled based on the results of the baseline assessment. All participants provided written willing consent to participate in the study.

The inclusion criteria were set as follows: age 60-80, man or woman, Charlson comorbidity index score of 3 or less, no history of serious cardiorespiratory disease, non-smokers (for at least last 6 months), able to walk for 6 minutes with / without a walking-aid, no diagnosed cognitive impairment impacting decision-making. Anyone who did not meet these criteria was not included in the study. The following table summarizes basic characteristics of the sample.

Table 1. Baseline characteristics of the participants. The brackets include units of measured outcome and scales of the outcome (categories of the BMI scores).

Baseline characteristics	**Total n=88**
Age (years), (mean ± SD)	70,59 ± 5,42
Sex female (n), (%)	75(85)
BMI (kg/m²), n (%)	
underweight (under 18.5)	0 (0)
healthy weight (18.5-25)	50 (56,8)
overweight (25-30)	24 (27,3)
obesity (above 30)	14 (15,9)
Weight (kg), (mean ± SD)	70,52 (14,1)
Height (m), (mean ± SD)	1,66 (0,9)

2.2 EXPERIMENTAL DESIGN

The randomization process was conducted as follows: A total of 96 sealed envelopes were prepared. Each group was represented by a specific number: 24 envelopes contained the number "1" for the first experimental group, 24 contained the number "2" for the second experimental group, 24 contained the number "3" for the third experimental group, and 24 contained the number "4" for the control group. Participants were then asked to randomly select one sealed envelope, which determined their group assignment. In the process, a total of 8 participants dropped out of the study. The data of these participants were not included within the study.

All participants underwent an interview and an initial assessment. Those who met all the inclusion criteria were enrolled in the study. During the initial examination, the patient's medical history, basic clinical data, and cognitive status were assessed. They then underwent a series of clinical tests, including the 6MWT. All participants who successfully finished the training protocol, underwent an identical examination after the end of the research to observe possible post-intervention changes in their health status.
All participants that were enrolled in the study were subsequently randomized into 1 of 4 groups:

Group 1: walking group
Group 2: walking + manual therapy group
Group 3: walking + resistance exercises group
Group 4: control group.

2.3 INTERVENTION

Group 1 (Walking): Participants engaged in regular walking sessions 2x/ week lasting 40 minutes each. The training was conducted in an indoor gym with a flat, dry surface. Walking intensity was regulated using the Borg Rating of Perceived Exertion (RPE) and progressively increased during each session.

Group 2 (Manual Therapy + Walking): Participants engaged 2x/week in exercise session which began with 20 minutes of self-administered manual techniques targeting the thoracic and cervical regions, followed by 40 minutes of walking identical to the protocol for Group 1. The manual techniques included soft tissue massage, stretching of thoracic and cervical muscles, and joint mobilization in the targeted regions. Participants were also educated on diaphragmatic breathing. The training protocol for manual therapy follows:

1. training of diaphragmatic breathing laying in the supine position (1’)
2. mobilization of cervical spine by active prolongment and traction of cervical spine in the supine position (15 repetitions)
3. mobilization of the shoulder girdle by circular motion of the shoulders in standing position (0,5’)
4. massage of intercostal muscles in the region parallel to sternum / thoracic vertebrae in standing position (2’)
5. mobilization of upper cervical spine and cervico-cranial joints by active movement in protraction / retraction of head in standing position (15 repetitions)
6. self-massage of sternocleidomastoid muscles in standing position (4’)
7. self-massage of trapezoid muscles in standing position (4’)
8. training of diaphragmatic breathing in standing position (1’)
9. mobilization of the spine in lateroflexion and stretching of lateral trunk muscles combined with diaphragmatic breathing (3’)
10. mobilization of shoulder blades by active movement of protraction and retraction combined with diaphragmatic breathing (15 repetitions)
11. same as 1. (1’)

Group 3 (Elastic Band Resistance Training + Walking): Participants completed 2x/week 20 minutes of elastic band resistance training followed by 40 minutes of walking, identical to the protocol for Group 1. The resistance training consisted of a series of exercises aimed at correcting kyphotic posture. Each session included three exercises performed in 3 sets of 10 repetitions per set for both shoulders, with a 1-

minute rest between sets. Over time, the number of repetitions was gradually increased to 12 as participants progressed. For the exercises, an elastic resistance band with 100%-300% extensibility and resistance ranging from 3.2 to 4.5 kg was used. These bands are commonly utilized in training interventions [25]. The exercises were designed based on existing research [25] and were performed in a seated position. The three exercises are described below.

1. The first exercise promoted external rotation in the shoulder joints and encouraged trunk straightening. In the first phase, the participant performed external rotation of the shoulder joints against the resistance of an elastic band, emphasizing an upright trunk posture through concentric contraction of the external shoulder rotators. In the second phase, the participant controlled the return movement into internal rotation, guided by the elastic band's tension, engaging the internal shoulder rotators eccentrically. The exercise leveraged the principle of reciprocal inhibition, reducing the activity of the internal rotators while strengthening the external rotators and supporting proper posture.
2. The second exercise supported the activity of the external rotators of the hip joints and the straightening of the trunk. In the first phase, participants performed a concentric contraction of the external hip rotators against the resistance of the elastic band. In the second phase, they engaged in an eccentric contraction of the external hip rotators while simultaneously controlling the straightening of the trunk. The exercise was combined with active external rotation of the arms.
3. The third exercise supported an upright posture and the opening of the ventral side of the chest. In the first phase, participants straightened their trunks against the resistance of the elastic band, engaging in concentric contraction of the trunk-straightening muscles. In the second phase, they controlled the movement as the trunk gradually bent forward under the pull of the elastic band, utilizing eccentric contraction.

Group 4 (No intervention): Participants were instructed to maintain their regular daily routines without making any changes.

3 STARTING POINT, OBJECTIVE, TASKS

3.1 OBJECTIVE OF THE STUDY

Our study aimed to evaluate the effect of regular walking and its combination with manual techniques or resistance band exercises on functional capacity in healthy elderly. Available research suggests that all these interventions have beneficial influence on overall health, however studies working with seniors without any specific diseases are still scarce. We hypothesize, that walking and its combination with subsequent interventions like manual therapy or resistance exercise has the potential to improve functional capacity in healthy seniors.

3.2 STATISTICAL ANALYSIS

Statistical analyses were performed using R software (version 4.3.2), and the results were examined to identify significant differences between and within the groups. Descriptive statistics, such as the mean, standard deviation, minimum, maximum, and the 1st and 3rd quartiles, were used to summarize the measured outcomes. The normality of the data was first assessed using the Shapiro-Wilk test. For normally distributed data, paired t-tests were employed to compare pre- and post-intervention walking distances within each group, while for non-normally distributed data, the Wilcoxon signed-rank test was applied. To evaluate differences between groups, the Kruskal-Wallis test was used, as it is a non-parametric test suitable for multiple independent groups with non-normal distributions. Effect size (ES) was determined using eta squared (η^2) to assess the magnitude of the differences, based on the Kruskal-Wallis test statistic, number of groups, and sample size. Outliers in the data were identified using box-plots and scatter-plots as well as the Interquartile Range (IQR) rule.

4 RESULTS

The Shapiro-Wilk test revealed that data were normally distributed in 3 out of 4 groups, with Group 2 being the exception, as its data did not follow a normal distribution. To analyze within-group changes in the 6-minute walking distance (6MWD), a paired t-test was applied to Groups 1, 3, and 4, while the Wilcoxon signed-rank test was used for Group 2 due to the non-normality of its data. Effect sizes, represented by eta-squared (η^2), were calculated for each comparison.

In Group 1, the paired t-test showed a significant decrease in 6MWD post-intervention compared to pre-intervention, despite the mean post-intervention distance (575.2 m) being higher than the mean pre-intervention distance (550.9 m). The mean paired difference was negative (-24.36 m), indicating that participants, on average, walked less post-intervention ($p = 0.011$). The effect size, as measured by eta squared (η^2), was 0.269, indicating a medium to large effect size. In Group 2, the mean pre-intervention walking distance (538.3 m) increased significantly to 557.9 m post-intervention, as revealed by the Wilcoxon test ($p = 0.028$). The effect size, calculated as eta squared (η^2), was 2.32, suggesting a very large effect of the intervention. No significant changes in 6MWD over time were observed in Groups 3 and 4, while the effect sizes (η^2) indicated a negligible effect of the intervention.

Post hoc pairwise comparisons were conducted using Dunn's test with Bonferroni correction to explore differences between groups for pre-intervention 6MWD and post-intervention 6MWD. For pre-intervention 6MWD, no significant differences were observed between any groups after adjusting p-values with the Bonferroni method. Although the unadjusted p-value for the comparison between Group 2 and Group 4 suggested a potential difference ($p = 0.011$), it was not significant after correction (adjusted $p = 0.067$). For post-intervention 6MWD, no significant differences were detected between any groups, with all Bonferroni-adjusted p-values being nonsignificant. These results are summarized in the table below.

Table 2. Within-group comparison of 6MWD (pre- and post-intervention)

		Group 1	Group 2	Group 3	Group 4
6MWD pre-intervention	Mean	550,9	538,3	561,5	576,5
	SD	53,7	76,7	56,5	44,6
	Min.	420	400	450	485
	1st Q	524,2	497,5	532,5	545
	3rd Q	585	568,8	591,5	610
	Max.	630	780	690	660
6MWD post-intervention	Mean	575,2	557,9	563,8	577,2
	SD	70,4	75,4	70,7	43,5
	Min.	450	415	410	495
	1st Q	560	512,5	515	542
	3rd Q	603,8	597,5	624	615
	Max.	710	800	685	660
p-value		0.011*	0.02*	0.824	0.886
effect size (η^2)		0.269	2.32	0.0023	0.00105

5 DISCUSSION

The aim of this study was to evaluate the effect of regular walking and its combination with manual therapy or resistance exercises on 6MWD in healthy older adults. The results showed a significant decrease in 6MWD in Group 1, while Group 2 showed a significant increase. Groups 3 and 4 did not yield any significant changes.

In Group 1, despite a higher mean distance post-intervention compared to pre-intervention, there was a significant decrease in 6MWD after the intervention. Seniors in this group underwent walking-based training twice a week, with each session lasting 40 minutes. The intensity was adjusted using the Borg Rating of Perceived Exertion (RPE) and gradually increased over time. The literature on walking-based interventions in healthy seniors and their impact on 6MWD is limited. However, existing research suggests that walking is an effective tool for improving various health outcomes in adults. Based on the literature, we propose that regular walking, as a training intervention, has the potential to improve 6MWD in older adults. Over time, walking leads to musculoskeletal improvements, such as increased muscle strength, endurance, and flexibility [26]. It also improves coordination, balance, and motor control in elderly individuals [27], as well as cardiorespiratory fitness [28]. Endurance activities like walking, when performed consistently, result in adaptations in skeletal muscle, including greater mitochondrial content and improved respiratory function of muscle fibers [29]. These changes are crucial for increasing the ability to sustain prolonged, intense exercise following endurance training [29]. Furthermore, regular walking positively impacts various biomechanical parameters of the lower limbs, including muscle activation and gait parameters, leading to greater stride length, walking speed, and efficiency [30]. Additionally, walking contributes to better mental health by reducing stress, anxiety, and negative mood [31].

Although our results did not show any significant improvement in 6MWD in Group 1, we believe that these biomechanical factors still hold potential to improve 6MWD in healthy adults when walking interventions are appropriately dosed. We hypothesize that the lack of improvement in Group 1 stemmed from discrepancies in the training dosage and the participants' fitness levels, rather than the absence of underlying biomechanical benefits of walking. A study by Anton et al. [28] investigated whether sedentary adults could improve their cardiorespiratory fitness by walking at moderate or vigorous intensities, in accordance with the 2007 ACSM/AHA guidelines. The results showed that leisurely-paced walking (moderate intensity) did not lead to fitness improvements, even with more than 150 minutes of walking per week. However, fast-paced walking (vigorous intensity) for 60-119 minutes per week resulted in increased VO2max for 60% of participants, with 71% of those walking more than two hours per week achieving clinically significant improvements. These findings support our claim that the benefits of walking interventions are likely dose related. In our study, participants performed walking training according to the Borg RPE scale, with each session beginning with a short warm-up period, followed by a gradual increase in walking performance starting at RPE grade 9 (light activity) and progressing to RPE grade 14 (somewhat hard activity). Our results align with Anton et al. [28], which suggests that moderate intensity activity, even when performed for 150 minutes a week, does not improve cardiorespiratory fitness in sedentary elderly individuals. For improvements to occur, the activity needs to be performed at vigorous intensity levels.

Additionally, the participants in our study were active seniors with a non-sedentary lifestyle, which could explain our results further. For more fit seniors, exercise at RPE levels of 9-14 may be relatively low intensity, as research indicates that individuals with higher fitness levels or more experience tend to benefit more from higher-intensity training (RPE 14-17, moderate to vigorous) in improving cardiovascular health and endurance, particularly in enhancing outcomes like the 6MWD [32]. In conclusion, regular walking has the potential to improve cardiorespiratory fitness in older adults, but to achieve meaningful results, the appropriate dosage in terms of frequency and intensity must be followed, especially for seniors with varying fitness levels.

Group 2 showed a significant increase in 6MWD post-intervention compared to pre-intervention. Participants in this group underwent 40 minutes of walking-based training twice a week combined with 20 minutes of manual therapy focusing on the thoracic and cervical region. Available literature supports beneficial effect of manual therapy on various health outcomes in individuals. Manual therapy can provide pain relief [33, 34], improved joint range of motion [35], muscle relaxation [23], mental health regulation [36] as well as improved lymphatic and blood flow [37]. We believe that the key benefits of manual therapy applied to the thoracic and cervical region for improving 6MWD include enhanced proprioception and reduced cervicogenic dizziness, which contribute to better postural stability [38]. Additionally, it supports respiratory function by improving breathing patterns, spirometry outcomes [39], and respiratory muscle strength [40].

Research on the combined effects of manual therapy and walking to assess the potential for increased intervention efficacy is still in its early stages. During our research, we have encountered only few studies examining the effect of manual therapy combined with walking or other type of aerobic exercise. Results of these studies suggest that combining manual therapy with walking or aerobic exercise has been shown to enhance outcomes for chronic low back pain [41, 42]. In one of these studies, participants underwent six weekly sessions of manual therapy, with additional prescribed exercise performed twice a day in order to achieve beneficial effect on chronic low back pain [42]. Given the limited availability of studies on cardiorespiratory fitness in adults that combine walking with manual therapy, we structured our exercise dosage based on World Health Organization (WHO) guidelines for physical activity in older adults [43], combining their recommendations for moderate-intensity aerobic exercise with the expertise of our peers in the field. The walking intensity at RPE range of 9-14 falls within these guidelines, offering an appropriate balance of effort without overwhelming the participants. By combining this with manual therapy, we aimed to incorporate holistic care, which can aid musculoskeletal health and potentially enhance the benefits of exercise. Manual therapy combined with walking may have had a synergistic positive effect on 6MWD through its influence on respiratory function, thoracic mobility, posture, and gait mechanics. We hypothesize that intervention in Group 2 enhanced walking efficiency, reduced energy expenditure, and promoted neuromuscular control, all of which contributed to better walking performance.

Given that Group 1 did not show significant improvement in 6MWD, while Group 2 did, we hypothesize that the superior results in Group 2 may be attributed to the holistic nature of the intervention. Although both groups shared similar baseline characteristics, the higher attendance in Group 2 could have influenced the outcomes, as motivation plays a crucial role in adherence to exercise programs [44]. To gain a deeper understanding of these results, further research is needed to explore the precise mechanisms and contributions of motivation, intervention structure, and consistency in more detail.

Group 3 in our study did not show significant changes in 6MWD over time. This group participated in 40 minutes of walking-based training twice a week, supplemented with 20 minutes of elastic band resistance exercises focused on posture correction. The initial dosage of resistance exercises consisted of 3 sets of 10 repetitions at an RPE of 10, with 1-minute rest intervals. Over time, the intensity and frequency of the exercises increased to 3 sets of 12 repetitions at an RPE of 14, while the rest period remained the same.

Previous studies have clearly highlighted the various health benefits of resistance training (RT) for elderly individuals, including improvements in muscle strength [45], body composition [46], muscle endurance [47], joint range of motion [48], sleep quality [48], 10-meter walking speed [48], and bone density [49]. Specifically, one study demonstrated that resistance training performed three times a week for 60 minutes per session at 70-80% of 1RM (one-repetition maximum), targeting major muscle groups, significantly improved knee strength, which is critical for walking performance [50]. Furthermore, a meta-analysis found that RT positively impacts joint range of motion [51].

While numerous studies [52, 53, 54] have shown that regular RT can enhance joint range of motion, we believe that the effects of RT on joint flexibility may be influenced by several factors. According to Alizadeh et al. [51], baseline fitness level plays a significant role in the effectiveness of RT on joint range of motion. Interestingly, factors such as age, sex, muscle contraction type in RT, or exercise dosage did not appear to influence the outcome. Notably, sedentary elderly individuals experienced a more significant improvement in joint range of motion compared to their more active counterparts [51].

Given these findings, we hypothesize that the lack of significant results in our study may be due to insufficient progression in the load of resistance training, the focus on lower limb muscles, and the inclusion of a highly active senior population.

Group 4 did not show any significant improvement in 6MWD. This group was a control group containing participants that maintained their daily routine. There was no expected improvement in this group as they did not participate in any kind of intervention.

As with all studies, this study has several limitations, including a predominantly female sample, the inclusion of highly fit seniors with a Charlson Comorbidity Index score of 3 or less, and a relatively short intervention duration. Additionally, the resistance training group did not experience sufficient progression in load intensity, which may have affected the results. These factors could have influenced the study's outcomes and warrant consideration in future research.

6 CONCLUSIONS

In conclusion, this study examined the effect of regular walking, combined with manual therapy or resistance exercises, on 6MWD in healthy older adults. The results revealed that while walking alone did not significantly improve 6MWD, combining walking with manual therapy led to a significant increase of 6MWD. The benefits of manual therapy, including improved proprioception, posture, and respiratory function, may have contributed to these positive outcomes. Conversely, the resistance training group did not show significant changes, possibly due to insufficient load progression and the high fitness level of the participants. The control group exhibited no changes, as expected.

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