Effect of Exergame boxing addition on appendicular muscle mass index in elderly women

Efecto de la adición de boxeo Exergame en el índice de masa muscular apendicular en mujeres mayores

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Abstract

Introduction: Elderly women tend to have higher adiposity than men of the same age, along with lower muscle mass and density. These factors increase the risk of impaired physical function and disability.
Objective: This study examines the effects of an 8-week exergame boxing program on appendicular muscle mass in elderly women.
Methodology: In this study, 30 elderly women are randomly assigned to two groups: control and intervention. The intervention group participates in exergame boxing sessions (30 minutes per session, 3 times a week) for eight weeks. Both groups perform low-intensity aerobic exercise for 15 minutes, five times a week. Before and after the intervention, all participants undergo Bioelectrical Impedance Analysis to evaluate their Appendicular Muscle Mass Index.
Results: In the control group, no significant gains in appendicular muscle mass index are observed after eight weeks of low-intensity aerobic exercise ($p = 0.070$). Conversely, the intervention group shows a significant increase in appendicular muscle mass index, with an effect size of 0.73 and statistical significance ($p < 0.001$). The change in appendicular muscle mass index is significantly greater in the intervention group compared to the control group ($p = 0.047$).
Discussion: This study highlights that an 8-week virtual reality-based exergame boxing program combined with low-intensity aerobic exercise significantly improves appendicular muscle mass in elderly women.
Conclusions: The addition of exergame boxing for eight weeks can increase the appendicular muscle mass index of elderly women as measured by Bioelectrical Impedance Analysis.

Keywords

Elderly women; exergame boxing; muscle mass; appendicular muscle mass index.

Resumen

Introducción: Las mujeres mayores tienden a tener mayor adiposidad que los hombres de la misma edad, junto con menor masa y densidad muscular. Estos factores aumentan el riesgo de deterioro de la función física y discapacidad.
Objetivo: Este estudio examina los efectos de un programa de boxeo basado en videojuegos durante 8 semanas sobre la masa muscular apendicular en mujeres mayores.
Metodología: En este estudio, 30 mujeres mayores se asignan aleatoriamente a dos grupos: control e intervención. El grupo de intervención participa en sesiones de boxeo virtual (30 minutos por sesión, 3 veces por semana) durante ocho semanas. Ambos grupos realizan ejercicio aeróbico de baja intensidad durante 15 minutos, cinco veces por semana. Antes y después de la intervención, todas las participantes se someten a un análisis de impedancia bioeléctrica para evaluar su índice de masa muscular apendicular.
Resultados: En el grupo control, no se observan ganancias significativas en el índice de masa muscular apendicular después de ocho semanas de ejercicio aeróbico de baja intensidad ($p = 0.070$). Por el contrario, el grupo de intervención muestra un aumento significativo en el índice de masa muscular apendicular, con un tamaño del efecto de 0.73 y significancia estadística ($p < 0.001$). El cambio en el índice de masa muscular apendicular es significativamente mayor en el grupo de intervención en comparación con el grupo control ($p = 0.047$).
Discusión: Este estudio resalta que un programa de boxeo basado en realidad virtual durante 8 semanas, combinado con ejercicio aeróbico de baja intensidad, mejora significativamente la masa muscular apendicular en mujeres mayores.
Conclusiones: La adición de un programa de boxeo virtual durante ocho semanas puede aumentar el índice de masa muscular apendicular de las mujeres mayores, medido mediante análisis de impedancia bioeléctrica.

Palabras clave

Mujeres mayores; boxeo virtual; masa muscular; índice de masa muscular apendicular.

Introduction

The reduction of muscle mass is a significant physiological change associated with aging, with a decline of approximately 1-2% by the age of 50. Furthermore, the deterioration of muscle strength in women typically commences between the ages of 40 and 75, manifesting at a rate of 48-92% (WHO, 2020). It has been observed that elderly women exhibit a higher level of adiposity compared to their male counterparts of the same age, alongside a decrease in both muscle mass and density. This disparity significantly elevates the risk of impaired physical function and disability. The concomitant reduction in muscle mass, coupled with an increase in body fat, renders the elderly population particularly susceptible to sarcopenia, a condition characterised by the progressive loss of muscle mass and strength (Shen et al., 2023).

Additionally, frailty, which is an age-related state of physiological vulnerability, is another condition associated with diminished musculoskeletal function and is notably prevalent among women (Nguyen et al., 2020). Various factors contribute to this decline, including chronic inflammation, obesity, muscle quality, insufficient physical activity, and inadequate nutrition, all of which adversely affect musculoskeletal function in the physically frail elderly (Lim & Frontera, 2023).

To combat these issues, multicomponent exercise has emerged as a beneficial intervention for older adults. This form of exercise integrates aerobic activities, strength training, balance exercises, and flexibility routines, demonstrating efficacy in enhancing muscle mass, strength, and overall physical performance. Notably, research has shown that higher training intensities can lead to more significant improvements in muscle strength and mass, particularly in older populations. For instance, a systematic review highlighted that resistance training at moderate to high intensities yields superior outcomes compared to low-intensity regimens (Beaudart et al., 2023). Furthermore, a meta-analysis indicated that resistance training effectively improves muscle strength and mass in individuals with secondary sarcopenia, underscoring the importance of training intensity in achieving optimal results (Currier et al., 2023).

The incorporation of technology through virtual environments, commonly referred to as exergames, leverages the principles of multicomponent exercise while also allowing for the adjustment of training intensity in a user-friendly manner. Exergames not only provide an engaging platform for physical activity but also facilitate the monitoring of performance metrics, enabling participants to progressively increase their training intensity (Jo et al., 2020; Moreira et al., 2021; Sadeghi et al., 2021).

Several studies have demonstrated the effectiveness of exergames in improving physical function and muscle mass among older adults. For example, a study by Hernandez-Martinez et al. (2024) found that older adults who engaged in exergaming showed significant improvements in balance and lower limb strength compared to those who did not participate in such activities. Additionally, a systematic review by Yu et al. (2020) concluded that exergames can be an effective tool for enhancing physical activity levels and improving muscle strength in older populations. A study conducted by Gallo et al. (2019) involving elderly women utilising the DanceCentral Xbox360 Kinect game over a 12-week period revealed significant improvements in both strength and muscle mass. Similarly, research by Biesek et al. (2021) among frail older women indicated that the combination of exergames with protein supplementation resulted in greater muscle mass gains compared to when these interventions were analysed in isolation.

This study aims to evaluate the effects of an 8-week intervention incorporating exergame boxing on the appendicular muscle mass index in elderly women residing in a nursing home in Surabaya, Indonesia. Although exergame boxing is not a novel method, its application in a structured intervention specifically targeting muscle mass improvement in elderly women is less explored. The significance of this study lies in its potential to adapt a widely accessible and engaging form of exercise to meet the specific needs of a vulnerable population, addressing the critical issue of sarcopenia in aging adults. By focusing on a population that may have limited access to traditional forms of exercise due to mobility or health constraints, this study seeks to demonstrate the feasibility and effectiveness of exergame boxing as a viable alternative to enhance muscle mass and strength. The underlying hypothesis posits that the appendicular muscle mass index will exhibit significant improvement following the 8-week exergame boxing intervention, particularly due to the ability to tailor training intensity to individual capabilities, thereby maximizing engagement and outcomes.

Method

Participants

This study includes elderly women aged 60 years and older residing in the Surabaya East Java Nursing Home, Kalijudan, who meet the following criteria: (1) They are able to walk without assistance; (2) They have good vision and hearing function; (3) They have stable hemodynamics; (4) They have a body mass index (BMI) of 18.5-24.9 kg/m^2; (5) They have normal cognitive function; (6) They are willing to participate by signing informed consent. The exclusion criteria are: (1) They have cardiorespiratory diseases that influence physical exercise; (2) They have neuromuscular disease; (3) They have sarcopenia and frailty at a moderate to severe level; (4) They have uncontrolled comorbidities, such as poorly controlled diabetes or hypertension; (5) They experience infectious processes at the beginning of the study period for any reason, such as infection by the SARS-CoV-2 virus with a positive RT-PCR test in the previous seven days; (6) They participate in another specified standardized physical training program during the three months prior to participation.

Study design

This experimental study employs a randomized control group design with pre- and post-tests, conducted at the Kalijudan Nursing Home in Surabaya using simple random sampling. Enrollment occurred from early June to July 31, 2023. The sample size was determined based on previous studies examining similar interventions, ensuring adequate power to detect significant differences. A pilot study was conducted to refine the methodology and ensure feasibility. The Bioelectrical Impedance Analysis (BIA) scores are compared before and after the intervention for assessment.

Intervention Group (IG): The IG undergoes exergame boxing three times a week. Sessions last 25 minutes and include movements such as jabs, crosses, hooks, and uppercuts performed rhythmically to music. The duration of each session increases by five minutes weekly over eight weeks. Participants are introduced to the exercise protocol during an initial meeting, with familiarization occurring one week before the study begins through three 15-minute sessions. Safety is overseen by researchers and nursing home staff, and participants complete an exercise supervision card after each session.

Control Group (CG): The CG performs 15 minutes of low-intensity aerobic exercise five days per week. This includes light activities such as walking, gentle stretching, and basic movements designed to enhance cardiovascular fitness without overexertion.

Ethical Approval

Ethical approval for the study was granted by the Health Research Ethics Commission of Dr. Soetomo General Hospital Surabaya (ethical feasibility number 0993/LOE/301.4.2/VIII/2023). Informed consent was obtained from all participants and their legal guardians prior to inclusion in the study.

Low-Intensity Aerobic Exercise

All participants adhere to a programmed low-intensity aerobic exercise regimen provided by the Kalijudan Nursing Home five times a week for 15 minutes. The exercise includes light activities such as walking, gentle stretching, and basic movements designed to enhance cardiovascular fitness without overexertion. Attendance and adherence to the exercise were closely monitored, achieving an adherence rate of 90%. This high level of adherence underscores the feasibility and acceptability of incorporating such exercises into the daily routine of elderly residents.

Exergame Boxing

The intervention group receives additional exergame boxing sessions three times a week, with each session lasting 25 minutes over the course of eight weeks, according to the exercise protocol. The sessions include a variety of movements such as jabs, crosses, hooks, and uppercuts, performed in a rhythmic manner to music, which enhances engagement and enjoyment. The duration of each session gradually increases by five minutes each week. Prior to commencing the exercise, participants are introduced to the exercise delivery protocol during the initial meeting. Familiarisation occurs one week before the

study begins, with three sessions a week for 15 minutes each. The safety of participants during the intervention is overseen by three researchers and nursing home staff. Participants are required to complete an exercise supervision card after each intervention session.

Outcomes

The primary outcome measure is the appendicular muscle mass index, which represents the sum of the lean muscle mass of the upper and lower extremities adjusted for height. This index is assessed in this study using the Bioimpedance Analysis HBF-375 prototype, which has a tool accuracy of 0.1 kg. This device measures electrical impedance in the body (Branco et al., 2023). The body composition measurements include body fat content, skeletal muscle mass, and metabolism. Subjects place their feet one by one onto the BIA unit, ensuring the soles of their feet are positioned above the foot electrodes. The examiner holds the electrodes and instructs the subject to grip them with both hands. The elbows are fully extended, and both shoulders are positioned in 90 degrees of flexion. When the full-body icon appears on the monitor, the unit measures. After the measurement, the subject steps down, and the examiner assists in releasing the grip electrodes. The measurement results are checked on the unit display by pressing the "Check area" and recorded.

Statistical analysis

All data obtained in this study are analysed using SPSS Statistics 26.0 (IBM Corp., Armonk). The Shapiro-Wilk test is used to check data normality. To compare the appendicular muscle mass index in the control and intervention groups before and after training, the paired t-test is used if the data is normally distributed, or the Wilcoxon Signed Rank test is applied if the data is not normally distributed. Effect sizes are calculated using Cohen's d to determine the magnitude of the intervention's impact, with interpretations as small (d = 0.2), medium (d = 0.5), and large (d = 0.8) based on Cohen's benchmarks (1988). Confidence intervals are provided to enhance result interpretation. A p-value is considered significant if $p < 0.05$.

Results

Thirty adult patients were included in this study based on pre-defined inclusion criteria. Additionally, three intervention participants did not complete the study, and one control participant withdrew. Data were analysed at the end of the study, resulting in 14 subjects from the control group and 12 subjects from the intervention group.

Table 1. The General Characteristics of Participants

Characteristic	Intervention Group (n=12) Means ± SD	p-value	Control Group (n=14) Means ± SD	p-value
Age (Years)	69.53 ± 5.77	0.887	71.27 ± 7.32	0.389
Body weight (kg)	49.47 ± 4.17	0.825	48.40 ± 5.21	0.389
Body height (cm)	146.63 ± 6.42	0.578	145.10 ± 8.01	0.113
Body Mass Index (kg/m^2)	23.00 ± 1.10	0.142	22.97 ± 1.28	0.155
Physical Activity	113.40 ± 9.29	0.397	113.47 ± 9.67	0.130
Nutritional status	11.13 ± 1.13	0.276	11.07 ± 1.39	0.140
ASMI (kg/m^2)	6.38 ± 0.56	0.208	6.77 ± 0.64	0.126
Comorbid				
Hypertension	8 (53.3%)		7 (46.7%)	
Diabetes Mellitus	5 (33.3%)		8 (53.3%)	
Others	0 (0%)		0 (0%)	

The intervention group initially included 15 participants, while the control group also included 15 participants. The comorbidity data indicated that 8 participants (53.3%) in the intervention group had hypertension, compared to 7 participants (46.7%) in the control group. Additionally, 5 participants (33.3%) in the intervention group had diabetes mellitus, while 8 participants (53.3%) in the control group had the same condition. The homogeneity test for all characteristics showed no statistically significant differences between the groups.

Table 2. ASMI between Intervention Group and Control Group (Before & After Intervention)

	Pre-Test	Post-Test	p-value	Effect Size	Confidence Interval (95%)
ASMI (Control Group)	6.64	6.73	0.070	0.15	[6.50, 6.96]
ASMI (Intervention Group)	6.36	7.22	<0.001	1.35	[6.95, 7.49]

Table 2 indicates that there was a slight, non-significant increase in the appendicular skeletal muscle mass index (ASMI) score in the control group after the low-intensity aerobic exercise. In contrast, the intervention group showed a significant increase in ASMI following the addition of exergame boxing, with a large intra-group effect size, indicating a substantial improvement.

Table 3. ASMI Scores between Intervention Group and Control Group after Intervention

	ASMI (Intervention Group)	ASMI (Control Group)	p-value	Effect Size	Confidence Interval (95%)
After Intervention	7.22	6.73	0.047	0.73	[0.02, 0.95]

After the intervention, the mean ASMI in the intervention group was significantly higher than that in the control group, with a medium to large effect size according to Cohen's benchmarks (1988). This suggests that the exergame boxing intervention was effective in improving muscle mass in the elderly women participating in the study.

Discussion

This study is the first conducted at the Kalijudan Surabaya Nursing Home to implement a low-to-moderate intensity aerobic exercise combined with exergame boxing as an 8-week virtual reality-based multimodal exercise training program aimed at enhancing muscle mass among elderly women.

The results of this investigation reveal that the control group, which engaged in low-intensity aerobic exercise, did not exhibit significant improvements in appendicular muscle mass parameters. This finding is consistent with the research conducted by Brightwell et al. (2019), which suggests that muscle mass gains are more commonly associated with moderate-intensity aerobic exercise sustained over a longer period, such as 24 weeks. The lack of improvement in the control group can likely be attributed to the insufficient intensity and duration of the exercise regimen, which may not have provided the necessary stimulus for cellular adaptation and muscle hypertrophy.

A cross-sectional study by Harber et al. (2009) supports the notion that aerobic exercise over time can induce hypertrophy of muscle fibers, thereby increasing muscle mass and functional capacity. In the context of this study, the absence of an increase in muscle mass index in the control group is likely due to the low intensity and shorter intervention duration of eight weeks, especially when compared to previous studies that employed longer and more intense exercise regimens. This discrepancy underscores the critical importance of exercise intensity and duration in achieving the cellular adaptations necessary for muscle mass improvement. A study by Zhang et al. (2024) found that older adults who regularly engage in moderate-intensity aerobic exercise experience improvements in maximal oxygen uptake and maintain muscle size, lower extremity strength, and relative power output during knee extension movements. While these findings support the idea that aerobic exercise can enhance functional capacity, they also suggest that such exercise may not provide sufficient muscle activity to maintain or increase muscle mass in elderly individuals (Amiri & Sheikholeslami-Vatani, 2023).

Conversely, the intervention group demonstrated a significant increase in the ASMI, with a p-value of <0.001 and an effect size of 0.73, indicating a medium effect. This effect size is noteworthy, as it suggests substantial practical significance of the intervention. The findings align with those of Gallo et al. (2019), who reported increased strength and muscle mass in elderly women using the Xbox 360 Kinect Dance Central game for 12 weeks. The significant effect size in our study highlights the effectiveness of combining low-intensity aerobic exercise with exergame boxing, which not only engages the upper limbs through dynamic punching movements but also requires balance and coordination, thereby activating trunk and lower limb muscles. This multifaceted approach may enhance physiological responses related to skeletal muscle metabolism (Biesek et al., 2021; Putra et al., 2021; Sadeghi et al., 2021).

The mean ASMI value is higher in the intervention group compared to the control group, indicating that exergame boxing, in addition to low-intensity aerobic exercise, is effective in enhancing appendicular muscle mass. This study is consistent with previous research by Park & Shin (2023), who assessed the effectiveness of a six-week exergame program in elderly women, which showed significant improvements in muscle mass parameters measured using Bioelectrical Impedance Analysis (BIA). Another study conducted by Bohannon (2019) also found an increase in muscle mass index in female elderly subjects after administering multimodal exergame for 12 weeks. A study by Jeon & Kim (2020), which assessed the effect of virtual reality exergame on muscle mass parameters, showed a significant difference in delta values between the treatment group (0.847) and the control group (0.061). The increase in muscle mass index is considered a response to the increase in appendicular muscle mass index with multimodal exercise from the exergame, and the increase in ASMI in the previous study is consistent with the results of this study. The increase in muscle mass index can be attributed to the comprehensive nature of the exergame boxing intervention. This program not only targets muscle hypertrophy through resistance and aerobic components but also enhances neuromuscular coordination and balance. By engaging multiple muscle groups simultaneously, the intervention likely stimulates greater muscle fiber recruitment and metabolic activity, leading to improved muscle mass and function.

Furthermore, the findings emphasize the importance of exercise variety in maintaining participant engagement. While regular aerobic exercise has been shown to improve quality of life and physical function, the repetitive nature of such exercises can lead to disinterest among elderly participants (Valenzuela et al., 2023). The incorporation of exergame boxing provides a more engaging alternative, which may contribute to the observed improvements in muscle mass. Previous studies have demonstrated that multimodal training, including resistance, aerobic, balance, and flexibility training, can significantly enhance physical function, muscle mass, and strength in the elderly population (Amarya et al., 2018; Chen et al., 2021; Güngör Başaran & Akal Yıldız, 2022; Jiang et al., 2022; Kartikasari et al., 2023). The strengths of this study lie in its innovative approach to exercise intervention and the use of virtual reality technology, which may enhance motivation and adherence among elderly participants. The significant effect size observed in our study further underscores the potential of this multimodal exercise program to improve muscle health in older adults.

This study has several limitations. The use of exergame boxing equipment requires a certain level of skill and understanding, which may not resemble daily activities easily applicable to the elderly. Assistance from nursing home staff was necessary during equipment operation to ensure safety during exercise. Future research should focus on developing other multicomponent exergame exercises with similar intensity that can effectively improve the physical function of the elderly, incorporating movements that mimic daily activities. Additionally, the absence of long-term monitoring and follow-up after the exercise limits the understanding of sustained effects, necessitating further research to determine the long-term impact of the exercise on appendicular muscle mass improvement.

Conclusions

This study concludes that low-intensity aerobic exercise combined with additional boxing exergames for eight weeks has a favorable effect on increasing appendicular muscle mass in elderly women compared to low-intensity aerobic exercise alone. The simultaneous movement of various limb and trunk muscles during boxing exergames enhances physiological responses that contribute to skeletal muscle protein metabolism. Additionally, the motivation generated by this enjoyable virtual game positively influences the increase in appendicular muscle mass index observed in this study. These findings support the recommendation for the routine implementation of boxing exergames for older adults living in nursing homes.

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