Investigating body composition metrics in hypertensive men aged 60-70 through walking football

Investigación de las métricas de composición corporal en hombres hipertensos de 60 a 70 años a través del fútbol caminado

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Abstract

Introduction: Hypertension is a common health concern among older adults, often associated with adverse changes in body composition. Effective lifestyle interventions targeting this demographic are critical for promoting healthier aging.
Objective: This study aimed to evaluate the impact of a twelve-week walking football program on body composition parameters in hypertensive men aged 60 to 70 years.
Methodology: A mixed ANOVA design (2 groups × 4 time points) was employed to assess body composition metrics, including body fat percentage (BFP), body mass index (BMI), waist-to-hip ratio (WHR), lean body mass (LBM), and waist-to-height ratio (WHtR). Assessments were conducted at baseline, and after the fourth, eighth, and twelfth weeks.
Results: the experimental group demonstrated significant reductions in BMI, BFP, WHR, and WHtR, along with a notable increase in LBM compared to the control group.
Discussion: The findings support existing evidence that structured physical activity, such as walking football, can positively influence body composition in older adults. This intervention appears particularly effective for hypertensive men.
Conclusions: Walking football may be a viable and impactful strategy for improving body composition and supporting healthy aging in hypertensive older men. Future research should explore long-term adherence and broader health outcomes.

Keywords

Body composition; hypertension; older adults; physical activity; walking football.

Resumen

Introducción: La hipertensión es un problema de salud común en los adultos mayores, a menudo asociada con cambios adversos en la composición corporal. Las intervenciones efectivas en el estilo de vida dirigidas a este grupo demográfico son fundamentales para promover un envejecimiento más saludable.
Objetivo: Este estudio tuvo como objetivo evaluar el impacto de un programa de fútbol caminado en los parámetros de composición corporal en hombres hipertensos de 60 a 70 años, en un período de doce semanas.
Metodología: Se utilizó un diseño de ANOVA mixto (2 grupos × 4 momentos de medición) para evaluar métricas de composición corporal, incluyendo porcentaje de grasa corporal (BFP), índice de masa corporal (IMC), relación cintura-cadera (RCC), masa corporal magra (LBM) y relación cintura-altura (RCE). Las evaluaciones se realizaron al inicio del estudio y después de la cuarta, octava y duodécima semana.
Resultados: El grupo experimental mostró reducciones significativas en IMC, BFP, RCC y RCE, junto con un aumento notable en LBM en comparación con el grupo control.
Discusión: Los hallazgos respaldan la evidencia existente de que la actividad física estructurada, como el fútbol caminado, puede influir positivamente en la composición corporal de los adultos mayores. Esta intervención parece ser particularmente efectiva para hombres hipertensos.
Conclusiones: El fútbol caminado puede ser una estrategia viable y efectiva para mejorar la composición corporal y fomentar un envejecimiento saludable en hombres mayores hipertensos. Investigaciones futuras deberían explorar la adherencia a largo plazo y resultados de salud más amplios.

Palabras clave

Composición corporal; hipertensión; adultos mayores; actividad física; fútbol caminado.

Introduction

With a globally aging population, addressing chronic conditions such as hypertension and poor body composition has become a critical public health priority. Globally, these challenges are mirrored in countries like India, where the proportion of individuals aged 60 and above has risen significantly, amplifying the public health burden (Visaria, 2001). This trend reflects broader global aging patterns while highlighting regional disparities that exacerbate healthcare challenges. Rural areas, home to 80% of India's elderly, face unique obstacles due to limited healthcare resources, underscoring the urgent need for accessible interventions to promote healthy aging (Bhat & Dhruvarajan, 2001). Hypertension, a major risk factor for cardiovascular disease, often coexists with poor body composition metrics, such as high body fat percentage and low lean body mass, compounding the risk of adverse health outcomes (de Simone et al., 2016).

Physical activity is widely recognized as essential for healthy aging, offering benefits such as improved cardiovascular health, functional ability, and body composition (Abou Sawan et al., 2023). For example, concurrent training programs have been shown to improve body composition by reducing visceral fat and fat mass while increasing muscle mass and strength in populations with obesity, highlighting their potential applicability in addressing poor body composition (Simón Mora et al., 2021). Tailored exercise programs for older adults, including walking-based interventions, have shown significant benefits like reduced arterial stiffness and enhanced cardiovascular function (Ungvari et al., 2023). However, older adults frequently encounter barriers to regular physical activity, such as fear of injury, low motivation, and social isolation, compounded by cultural perceptions that sports are unsuitable for their age group (Suryadi et al., 2024; Syaukani et al., 2024).

Walking football, a modified, low-impact version of traditional football, has emerged as a promising intervention for older adults, offering preliminary evidence of improved cardiovascular health, mobility, and psychosocial well-being (McBain & Broom, 2022; Loadman, 2019). Its rules—restricting players to walking, limiting physical contact, and enforcing ball height restrictions—minimize the risk of injury while enhancing cardiovascular health (Costa et al., 2024). By combining safety with familiarity, walking football encourages sustained participation, addressing both physical inactivity and social isolation. Its controlled pace and reduced intensity make it particularly suitable for individuals managing hypertension, aligning with recommended physical activity guidelines for older populations (Egger et al., 2024). While robust longitudinal data are limited, studies have highlighted its potential to enhance both physical and mental health outcomes (Friedrich & Mason, 2017; White et al., 2021). This demographic often faces challenges such as reduced physical activity tolerance and heightened cardiovascular risks, which walking football addresses through its moderate intensity and structured nature. Early evidence suggests that such modified sports can enhance psychosocial well-being and reduce cardiovascular risks in aging populations (Reddy et al., 2017; Andersson et al., 2023).

Despite its growing popularity, research on walking football remains limited, particularly regarding its effects on body composition in hypertensive men. Most existing studies focus on general health and psychosocial outcomes, overlooking their potential impact on critical metabolic and cardiovascular markers in high-risk groups. Metrics such as BMI, waist-to-hip ratio, body fat percentage, lean body mass, and waist-to-height ratio are well-established indicators of cardiovascular and metabolic health but remain underexplored in relation to walking football interventions (Arnold et al., 2015). This is a significant gap, as poor body composition, when combined with hypertension, exacerbates cardiovascular risks and diminishes quality of life (Koliaki et al., 2019). Addressing this issue is essential to understanding how tailored physical activity interventions like walking football can mitigate these risks and improve health outcomes in aging populations (Corepal et al., 2020).

This study aims to investigate the effects of a twelve-week walking football program on key body composition metrics in hypertensive men aged 60–70. By targeting this high-risk demographic and focusing on understudied parameters, this research contributes to the growing evidence supporting modified sports as scalable and effective public health interventions. We hypothesize that regular participation in walking football will significantly improve body composition metrics, including reductions in body fat percentage and waist-to-hip ratio and increases in lean body mass, ultimately mitigating cardiovascular risks and advancing healthier aging.

Method

Participants

This study recruited 60 hypertensive men aged 60–70 years from local communities in Kashmir, India. Participants were screened through local health clinics and community centers. Eligibility criteria included:

1. Systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg was measured using the Omron Automatic Blood Pressure Monitor (HEM 7120), in line with the standardized guidelines provided by Schutte (2018) and supported by its prior validation (Zhang et al., 2021).
2. No participation in organized physical activity within the past six months.
3. Absence of medical conditions contraindicating exercise, such as uncontrolled diabetes, severe orthopedic issues, advanced heart disease, or other conditions listed in the American College of Sports Medicine (ACSM, 2013) guidelines for exercise testing and prescription.

Blood pressure was measured three times at each time point, with a two-minute interval between readings. The average of the three readings was calculated, following standardized guidelines for accurate assessment of hypertensive populations (Whelton et al., 2018). Participants were instructed to rest for five minutes before measurements and to avoid caffeine, alcohol, and vigorous activity for at least 12 hours beforehand. Exclusion criteria included any recent surgeries, physical impairments limiting mobility, or conditions that could be exacerbated with physical activity. Recruitment intentionally targeted hypertensive individuals to examine their physiological responses to the intervention.

Participants were randomly assigned to the experimental group (n = 30) or the control group (n = 30) using block randomization (block size of 6). Allocation sequences were generated using computer software, and group assignments were concealed using sealed opaque envelopes prepared by a research assistant not involved in the study. Researchers conducting baseline assessments were blinded to group allocation.

Sample Size and Power Analysis

A priori power analysis was conducted using G*Power (3.1.9.7) to determine the required sample size for a 4×2 mixed-design ANOVA (four time points × two groups). The analysis assumed:

- Medium effect size (f = 0.25), based on similar interventions in exercise and blood pressure studies.
- Alpha level (α) = 0.05.
- Power ($1-\beta$) = 0.80.
- Repeated measures correlation conservatively estimated at 0.5.
- Non-sphericity correction factor (ϵ) set to 1, assuming sphericity.

The results indicated a minimum sample size of 24 participants (12 per group). However, to enhance statistical robustness and generalizability, the study recruited 60 participants (30 per group). This larger sample size increased the study's actual power to 0.82, ensuring adequate sensitivity to detect medium-sized effects in the interaction between time and group.

Procedure

The experimental group participated in a 12-week walking football program designed specifically for older adults. Sessions were conducted three times per week, lasting one hour each. Each session comprised:

- 10-minute warm-up focusing on joint mobility and light stretching.
- 45 minutes of gameplay in a five-a-side walking football format.
- 5-minute cool-down with static stretching and relaxation exercises.

Gameplay adhered to strict walking rules, limited physical contact, and restricted ball height to reduce injury risk. Coaches and referees enforced these rules, ensuring compliance. The 5-a-side format was chosen to ensure consistent participation and engagement, as the sample size of 30 participants allowed for the formation of balanced teams. Smaller team sizes ensure that participants remain actively involved in the game, promoting moderate-intensity physical activity suitable for hypertensive older adults. This format aligns with guidelines outlined in the European Football for Development Network's Walking Football Practitioner's Guide, which emphasizes safety and sustained activity for older populations (European Football for Development Network, 2017). Exercise intensity was monitored using the Borg Rating of Perceived Exertion (RPE) scale, maintaining activities within moderate-intensity guidelines (Williams, 2017). Blood pressure was measured pre- and post-session to track immediate physiological responses. A medical professional was present at all sessions to manage potential adverse events and ensure participant safety.

Participants in the control group did not engage in structured exercise during the 12-week intervention. Weekly phone check-ins were conducted to document sedentary behavior, walking hours, and other physical activities. These interactions were strictly administrative and focused on documentation rather than motivation, ensuring minimal risk of influencing participant behavior.

Data Collection Procedures

Baseline and follow-up measurements were conducted at the Shalimar Medicate Clinic in Srinagar, India, one week before and after the intervention, as well as at weeks 4 and 8.

1. Body Composition:
   - Lean body mass (LBM), body fat percentage (BFP), and body mass index (BMI) were measured using the Omron body composition analyzer (HBF-375), which has been validated for older adults (Vasold et al., 2019; Gibson et al., 2000).
   - Waist circumference, hip circumference, and height were recorded to calculate the waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR).
2. Blood Pressure:
   - SBP and DBP were assessed at each time point using the Omron HEM 7120, calibrated before every session.
   - Participants were instructed to avoid caffeine, alcohol, and vigorous activity for 12 hours prior to measurements.
3. Standardization:
   - All measurements were conducted between 7:00 AM and 9:00 AM after an overnight fast. This specific time window was chosen to standardize hydration levels and minimize the effects of circadian variation on body composition and blood pressure metrics (Perrier et al., 2013).

Ethics Approval and Consent

This study adhered to ethical guidelines and was approved by the Department of Physical Education and Sports Sciences at the University of Delhi. Ethical approval was obtained from the Department Research Committee and the Board of Research Studies. All participants provided informed consent after being briefed about the study's purpose, procedures, and their rights. The Physical Activity Readiness Questionnaire (PAR-Q) was administered to ensure participant safety and suitability for physical activity. Confidentiality and privacy were upheld throughout the study in accordance with national and institutional standards.

Data analysis

Data analysis utilized a mixed-design ANOVA to examine differences in body composition metrics across groups (experimental vs. control) and over time (baseline, 4th, 8th, and 12th weeks). Before performing the mixed-design ANOVA, assumptions of normality, homogeneity of variances, and sphericity were evaluated. The Shapiro-Wilk test confirmed that all dependent variables met the assumption of normality ($p > 0.05$). Levene's test verified the homogeneity of variances across groups ($p > 0.05$). However, Mauchly's test indicated violations of sphericity ($p < 0.05$), necessitating the application of Huynh-Feldt corrections to adjust the degrees of freedom appropriately. These diagnostic tests support the suitability of the mixed-design ANOVA for analyzing the data. Descriptive statistics, including means and standard deviations, are presented to summarize the data. All analyses were performed using SPSS Statistics (Version 29), with the significance level set at $\alpha = 0.05$. Effect sizes were computed to supplement inferential results and provide a practical interpretation of the findings. Reporting followed APA guidelines to ensure clarity, precision, and consistency.

Results

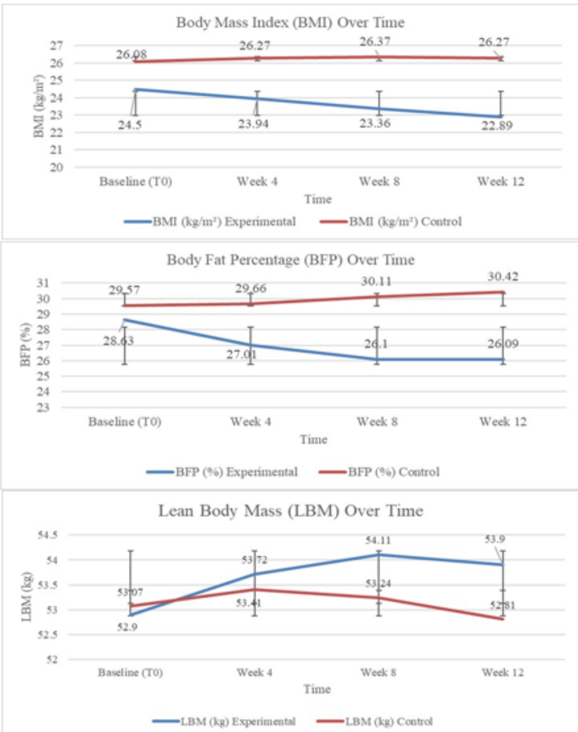
Over the twelve-week intervention period, significant changes were observed in body composition metrics among hypertensive men aged 60–70 who participated in the walking football program. The experimental group, engaging in thrice-weekly sessions of walking football, demonstrated notable improvements in physiological parameters, as shown in Table 1, which provides the descriptive analysis of body mass index (BMI), body fat percentage (BFP), lean body mass (LBM), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) across baseline, 4-week, 8-week, and 12-week assessments. In contrast, the control group, which did not engage in the intervention, showed minimal or no significant changes in these metrics over the same period.

Table 1. Descriptive Analysis of Body Composition Metrics Over Time for Experimental and Control Groups

Metric	Group	Baseline (T0)	Week 4	Week 8	Week 12 (T3)
BMI (kg/m^2)	Experimental	24.50 ± 2.55	23.94 ± 2.46	23.36 ± 2.45	22.89 ± 2.26
	Control	26.08 ± 2.81	26.27 ± 2.95	26.37 ± 2.95	26.27 ± 2.90
BFP (%)	Experimental	28.63 ± 4.24	27.01 ± 3.90	26.10 ± 4.07	26.09 ± 3.91
	Control	29.57 ± 4.36	29.66 ± 4.19	30.11 ± 4.40	30.42 ± 4.46
LBM (kg)	Experimental	52.90 ± 5.44	53.72 ± 5.61	54.11 ± 5.48	53.90 ± 5.30
	Control	53.07 ± 3.79	53.41 ± 3.97	53.24 ± 3.81	52.81 ± 3.74
WHR	Experimental	0.97 ± 0.05	0.95 ± 0.05	0.94 ± 0.05	0.92 ± 0.05
	Control	0.98 ± 0.05	0.99 ± 0.05	0.99 ± 0.05	1.00 ± 0.05
WHtR	Experimental	0.54 ± 0.05	0.52 ± 0.05	0.51 ± 0.05	0.51 ± 0.05
	Control	0.54 ± 0.04	0.54 ± 0.04	0.54 ± 0.04	0.54 ± 0.05

Note: Values are expressed as means ± standard deviations. T0 = Baseline, T3 = Week 12.

Figure 1. Changes in BMI, BFP and LBM over time, with error bars showing standard deviations

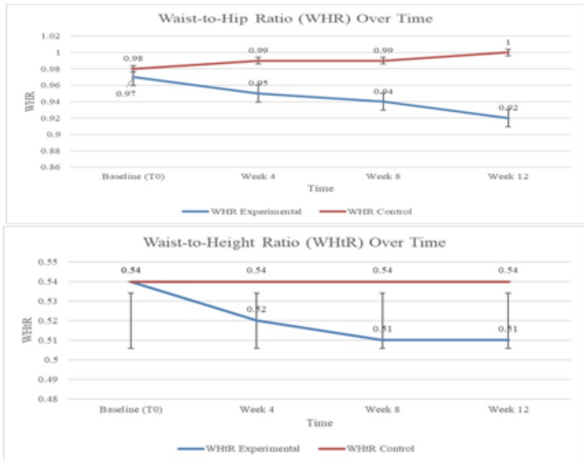


The experimental group demonstrated substantial changes in body composition metrics over the 12-week intervention period. BMI in the experimental group decreased significantly from 24.50 ± 2.55 kg/m² at baseline (T0) to 22.89 ± 2.26 kg/m² at week 12 (T3), while the control group showed minimal changes (26.08 ± 2.81 to 26.27 ± 2.90 kg/m²). Similarly, BFP in the experimental group reduced from 28.63 ± 4.24% at T0 to 26.09 ± 3.91% at T3, with little change observed in the control group (29.57 ± 4.36% to 30.42 ± 4.46%).

Conversely, LBM increased significantly in the experimental group, rising from 52.90 ± 5.44 kg at T0 to 53.90 ± 5.30 kg at T3. The control group experienced a slight decrease in LBM over the same period, declining from 53.07 ± 3.79 kg to 52.81 ± 3.74 kg. These trends are visually depicted in Figure 1, which highlights changes in BMI, BFP, and LBM across the four time points.

Central adiposity indicators also improved markedly in the experimental group. WHR decreased from 0.97 ± 0.05 at T0 to 0.92 ± 0.05 at T3, while WHtR reduced from 0.54 ± 0.05 to 0.51 ± 0.05 over the same period. The control group showed no meaningful changes in these metrics, with WHR increasing slightly from 0.98 ± 0.05 to 1.00 ± 0.05 and WHtR remaining stable at 0.54 ± 0.04. These results are illustrated in Figure 2, which tracks WHR and WHtR over time.

Figure 2. Changes in WHR and WHtR over time, with error bars showing standard deviations



Error bars in Figures 1 and 2 represent 95% confidence intervals, providing a visual representation of variability within each group at each time point.

Validation of Assumptions for Mixed ANOVA

Mixed ANOVA requires several assumptions to ensure valid and reliable results. These include:

1. Normality: The residuals of the dependent variables within each group and time point must follow a normal distribution.
2. Homogeneity of Variances: The variance across groups and conditions should be approximately equal.
3. Sphericity: The variances of the differences between repeated measures should be equal.

The following tests were conducted to assess these assumptions.

1. Normality: Normality of the dependent variables was assessed using the Shapiro-Wilk test. All variables met the assumption of normality ($p > 0.05$).
2. Homogeneity of Variances: Levene's test was conducted to assess the equality of variances across the groups. All variables satisfied the assumption of homogeneity of variances ($p > 0.05$).
3. Sphericity: Sphericity was tested using Mauchly's test, which indicated significant violations ($p < 0.05$) for all variables. As a result, the Huynh-Feldt correction was applied to adjust for these

violations, as it is appropriate for epsilon values close to 1, ensuring accurate results without excessive conservatism.

Table 2. Assumption Testing for Mixed ANOVA: Normality, Homogeneity of Variances, and Sphericity of Body Composition Metrics

Metric	Normality (*p*-value)	Homogeneity of Variances (*p*-value)	Sphericity (*p*-value)	Notes
BMI (kg/m²)	$p > 0.05$ (Shapiro-Wilk test)	$p > 0.05$ (Levene's test)	$p < 0.05$ (Mauchly's test)	Sphericity violated; Huynh-Feldt correction (ε = 0.88) applied.
BFP (%)	$p > 0.05$ (Shapiro-Wilk test)	$p > 0.05$ (Levene's test)	$p < 0.05$ (Mauchly's test)	Sphericity violated; Huynh-Feldt correction (ε = 0.88) applied.
LBM (kg)	$p > 0.05$ (Shapiro-Wilk test)	$p > 0.05$ (Levene's test)	$p < 0.05$ (Mauchly's test)	Sphericity violated; Huynh-Feldt correction (ε = 0.88) applied.
WHR	$p > 0.05$ (Shapiro-Wilk test)	$p > 0.05$ (Levene's test)	$p < 0.05$ (Mauchly's test)	Sphericity violated; Huynh-Feldt correction (ε = 0.82) applied.
WHtR	$p > 0.05$ (Shapiro-Wilk test)	$p > 0.05$ (Levene's test)	$p < 0.05$ (Mauchly's test)	Sphericity violated; Huynh-Feldt correction (ε = 0.86) applied.

Note: Sphericity was violated for all variables ($p < 0.05$), so the Huynh-Feldt correction (ε) was applied to adjust for this violation.

Overall, the assumptions required for conducting a mixed ANOVA were tested and addressed appropriately. Normality and homogeneity of variances were satisfied, while sphericity violations were corrected using the Huynh-Feldt adjustment. This validates the appropriateness of mixed ANOVA for analyzing the data.

Table 3. Mixed ANOVA Results for Body Composition Metrics

Metric	Source of Variation	Sphericity Correction	Sum of Squares	*df*	Mean Square	*F*	*p*	$\eta^2 p$
BMI (kg/m²)	Time	Huynh-Feldt	17.08	2.58	6.61	20.14	< 0.001	0.26
	Time * Group		28.48	2.58	11.03	33.59	< 0.001	0.37
	Group		398.61	1	398.61	14.53	< 0.001	0.20
BFP (%)	Time	Huynh-Feldt	35.20	2.60	13.52	15.58	< 0.001	0.21
	Time * Group		107.48	2.60	41.28	47.57	< 0.001	0.45
	Group		534.91	1	534.91	7.85	0.01	0.12
LBM (kg)	Time	Huynh-Feldt	17.00	2.65	5.68	7.19	< 0.001	0.11
	Time * Group		14.60	2.65	4.87	6.16	< 0.001	0.10
	Group		16.70	1	16.70	0.19	0.66	0.00
WHR	Time	Huynh-Feldt	0.01	2.46	0.00	9.43	0.01	0.14
	Time * Group		0.04	2.46	0.01	60.61	< 0.001	0.51
	Group		0.11	1	0.11	12.90	< 0.001	0.18
WHtR	Time	Huynh-Feldt	0.01	2.57	0.00	42.10	< 0.001	0.42
	Time * Group		0.01	2.57	0.00	53.30	< 0.001	0.48
	Group		0.03	1	0.03	3.17	0.08	0.05

Note: Partial $\eta^2 p$ values indicate effect sizes, interpreted as 0.01 (small), 0.06 (medium), and 0.14 (large). Huynh-Feldt corrections were applied for sphericity violations.

Table 3 presents the results of the mixed ANOVA for body composition metrics, including Body Mass Index (BMI), Body Fat Percentage (BFP), Lean Body Mass (LBM), Waist-to-Hip Ratio (WHR), and Waist-to-Height Ratio (WHtR). The analysis evaluates the main effects of time and group, as well as time-by-group interactions. Sphericity corrections were applied using the Huynh-Feldt adjustment where necessary, ensuring accurate *F*-statistics. Partial eta squared ($\eta^2 p$) values are reported as measures of effect size, with thresholds of 0.01 (small), 0.06 (medium), and 0.14 (large).

Significant time-by-group interactions were observed across all metrics, reflecting differential changes between the experimental and control groups over time:

- BMI: $F\,(2.58, 28) = 33.59$, $p < .001$, $\eta^2 p = 0.37$
- BFP: $F\,(2.60, 28) = 47.57$, $p < .001$, $\eta^2 p = 0.45$
- LBM: $F\,(2.65, 28) = 6.16$, $p < .001$, $\eta^2 p = 0.10$
- WHR: $F\,(2.46, 28) = 60.61$, $p < .001$, $\eta^2 p = 0.51$
- WHtR: $F\,(2.57, 28) = 53.30$, $p < .001$, $\eta^2 p = 0.48$

These significant interactions suggest that the experimental group experienced greater and more favorable changes in body composition metrics over time compared to the control group. For BMI, the large interaction effect (η^2p = 0.37) highlights a meaningful reduction in body mass among participants in the intervention group, underscoring its effectiveness in promoting weight loss. Similarly, the significant interaction for BFP (η^2p = 0.45) demonstrates substantial fat loss in the experimental group, while the control group showed minimal changes.

The large time-by-group interaction observed for WHR (η^2p = 0.51) indicates a marked reduction in central adiposity among the experimental group, a critical improvement given the association between abdominal fat and cardiometabolic risk. WHtR (η^2p = 0.48) showed a similarly pronounced interaction effect, with the experimental group demonstrating consistent and progressive reductions, particularly from Week 8 to Week 12, suggesting cumulative benefits from sustained participation in the intervention.

While the interaction effect for LBM was smaller (η^2p = 0.10), it remains significant, indicating that the intervention successfully preserved lean mass despite significant reductions in fat mass. This preservation of lean mass is critical for maintaining metabolic health and functional fitness, particularly in overweight and obese populations.

In terms of main effects, significant time effects were observed for all metrics, with progressive improvements across the intervention period. Significant group effects for BMI (η^2p = 0.20), BFP (η^2p = 0.12), and WHR (η^2p = 0.18) further highlight the superior outcomes achieved by the experimental group compared to the control group.

Overall, these findings demonstrate the intervention's substantial impact on body composition, with notable reductions in BMI and BFP reflecting improvements in overall adiposity. The observed large effect sizes for WHR and WHtR underscore the program's potential to mitigate risks associated with abdominal obesity, while the significant but smaller changes in LBM reflect a focus on fat reduction rather than muscle hypertrophy. Together, these results provide compelling evidence for the intervention's practical and clinical relevance in addressing obesity-related health risks.

Table 4. Pairwise comparisons of BMI, BFP and LBM for experimental and control groups with Bonferroni corrections for multiple comparisons

Metrics	Time Points (Groups)	Mean difference	SE	*df*	*t*	*p*
BMI (kg/m^2)	T0 (Exp.) vs. T0 (Control)	1.58	0.69	58	2.28	0.73
	T1 (Exp.) vs. T1 (Control)	2.33	0.70	58	3.32	0.04
	T2 (Exp.) vs. T2 (Control)	3.02	0.68	58	4.22	< 0.001
	T3 (Exp.) vs. T3 (Control)	3.38	0.67	58	5.04	< 0.001
	T0 (Exp.) vs. T1 (Exp.)	0.56	0.11	58	4.91	< 0.001
	T0 (Exp.) vs. T2 (Exp.)	1.14	0.16	58	7.22	< 0.001
	T0 (Exp.) vs. T3 (Exp.)	1.61	0.16	58	10.24	< 0.001
BFP (%)	T0 (Exp.) vs. T0 (Control)	0.94	1.11	58	0.85	1.00
	T1 (Exp.) vs. T1 (Control)	2.66	1.05	58	2.54	0.38
	T2 (Exp.) vs. T2 (Control)	4.01	1.09	58	3.67	0.02
	T3 (Exp.) vs. T3 (Control)	4.33	1.08	58	4.00	0.01
	T0 (Exp.) vs. T1 (Exp.)	1.62	0.25	58	6.40	< 0.001
	T0 (Exp.) vs. T2 (Exp.)	2.53	0.27	58	9.25	< 0.001
	T0 (Exp.) vs. T3 (Exp.)	2.54	0.23	58	11.23	< 0.001
LBM (kg)	T0 (Exp.) vs. T0 (Control)	0.17	1.21	58	0.14	1.00
	T0 (Exp.) vs. T1 (Exp.)	0.83	0.24	58	3.50	0.03
	T0 (Exp.) vs. T2 (Exp.)	1.22	0.28	58	4.40	< 0.001
	T0 (Exp.) vs. T3 (Exp.)	1.01	0.25	58	4.02	0.01

Note: T0 = Baseline, T1 = Week 4, T2 = Week 8, T3 = Week 12; Exp. = Experimental group, Control = Control group.

The Bonferroni method was used to adjust *p*-values for multiple comparisons to reduce the risk of Type I errors. This correction ensures that the observed significance levels are not inflated due to repeated tests on the same dataset.

Table 4 provides pairwise comparisons for BMI, BFP, and LBM using Bonferroni adjustments to ensure statistical rigor.

Key Findings:

1. BMI (kg/m²):
   - No baseline differences were observed between groups (*p* = 0.73).
   - Significant reductions were observed in the experimental group compared to the control group at all post-intervention time points (e.g., T3: mean difference = 3.38, *p* < 0.001).
   - Within the experimental group, BMI showed sustained declines across time (e.g., T0 vs. T3: mean difference = 1.61, *p* < 0.001).
2. BFP (%):
   - Baseline parity was confirmed (*p* = 1.00).
   - Group differences became significant by Week 8 (T2: mean difference = 4.01, *p* = 0.02) and increased at T3 (mean difference = 4.33, *p* = 0.01).
   - Within-group analyses revealed consistent reductions in the experimental group (e.g., T0 vs. T3: mean difference = 2.54, *p* < 0.001).
3. LBM (kg):
   - No significant baseline differences were observed (*p* = 1.00).
   - Modest gains in LBM were noted within the experimental group (e.g., T0 vs. T2: mean difference = 1.22, *p* < 0.001).

These findings indicate that the walking football program elicited marked improvements in BMI and BFP, with modest yet significant enhancements in LBM.

Table 5. Pairwise comparisons of WHR and WHtR for experimental and control groups with Bonferroni corrections for multiple compariso

Metrics	Time Points (Groups)	Mean difference	SE	*df*	*t*	*p*
WHR	T0 (Exp.) vs. T0 (Control)	0.01	0.01	58	0.56	1.00
	T1 (Exp.) vs. T1 (Control)	0.04	0.01	58	3.03	0.10
	T2 (Exp.) vs. T2 (Control)	0.05	0.01	58	4.08	< 0.001
	T3 (Exp.) vs. T3 (Control)	0.08	0.01	58	6.35	< 0.001
	T0 (Exp.) vs. T1 (Exp.)	0.02	0.00	58	8.12	< 0.001
	T0 (Exp.) vs. T2 (Exp.)	0.03	0.00	58	8.30	< 0.001
	T0 (Exp.) vs. T3 (Exp.)	0.05	0.00	58	11.48	< 0.001
WHtR	T0 (Exp.) vs. T0 (Control)	0.00	0.01	58	0.28	1.00
	T0 (Exp.) vs. T1 (Exp.)	0.01	0.00	58	8.70	< 0.001
	T0 (Exp.) vs. T2 (Exp.)	0.02	0.00	58	12.67	< 0.001
	T0 (Exp.) vs. T3 (Exp.)	0.02	0.00	58	14.44	< 0.001

Note: T0 = Baseline, T1 = Week 4, T2 = Week 8, T3 = Week 12; Exp. = Experimental group, Control = Control group.

Table 5 summarizes pairwise comparisons for WHR and WHtR with Bonferroni corrections applied

Key Observations:

1. WHR:
   - Baseline differences were non-significant (*p* = 0.72).
   - Significant reductions in WHR were observed in the experimental group compared to the control group, particularly at T2 and T3. By T2, the experimental group showed a mean difference of 0.05 compared to the control group (*p* < 0.001), indicating substantial improvement. The results at later time points, such as T3, further highlighted this trend (mean difference = 0.08, *p* < 0.001).
   - Within-group declines were steady over time (e.g., T0 vs. T3: mean difference = 0.05, *p* < 0.001).
2. WHtR:
   - Groups were matched at baseline (*p* = 1.00).

- The experimental group showed significant improvements across all time points (e.g., T0 vs. T3: mean difference = 0.02, $p < 0.001$).

These results demonstrate significant reductions in central adiposity markers, with WHR and WHtR showing robust improvements in the experimental group. The findings highlight the intervention's efficacy in addressing critical health risks related to metabolic syndrome.

Raw Data Availability Statement

The raw data supporting the findings of this study are not publicly available due to concerns related to participant confidentiality and privacy. However, specific data subsets may be made available by the corresponding author upon reasonable request and subject to ethical approval.

Discussion

This study evaluated the effectiveness of a 12-week walking football program on body composition among hypertensive older men, demonstrating significant reductions in BMI, BFP, WHR, and WHtR, along with a modest increase in LBM. These findings underscore the potential of walking football as a feasible and effective intervention for improving body composition in this demographic. The observed reductions in fat mass and central adiposity markers (WHR, WHtR) likely stem from increased energy expenditure, fat oxidation, and metabolic adaptations stimulated by regular physical activity (Paterson et al., 2007). However, the modest increase in LBM ($\eta^2 p = 0.10$) indicates that while the intervention preserved lean mass, it did not induce substantial hypertrophy. This outcome may reflect the moderate intensity of walking football, which, although effective for fat loss, may lack the high resistance or progressive overload required for significant muscle growth in older adults (Khodadad Kashi et al., 2023). Future studies should explore whether combining walking football with resistance training can amplify LBM gains (Di Lorito et al., 2020).

Although improved body composition often correlates with cardiovascular benefits, such as reduced visceral fat and systemic inflammation, direct measurements of cardiovascular markers were not part of this study. Thus, claims regarding cardiovascular improvements remain speculative and should be interpreted cautiously. Future research should assess vascular compliance, endothelial function, and inflammatory biomarkers to substantiate these hypotheses (Hegde & Solomon, 2015; Mendizábal et al., 2013).

The intervention's success may also reflect its cultural and social suitability within the Indian context, where physical activity levels in older adults are typically low, and community-oriented sports can foster adherence and engagement (Kumar, 2022). Walking football's low injury risk, simplicity, and social interaction likely enhanced motivation and long-term participation (Taylor & Pringle, 2022; Thomas, 2024). To further strengthen this argument, research on physical activity trends and social sports participation among older adults in India is essential (Tewari, 2021).

This study aligns with previous research showing exercise benefits for older adults. For instance, Manton et al. (1993) emphasized functional health improvements, while Westerterp et al. (1992) observed direct links between physical activity and body composition. However, both focused on populations distinct from hypertensive older adults, limiting direct comparability. Unlike Arnold et al. (2015), who studied walking football in general older populations, this study uniquely addresses the interplay of hypertension-specific factors, such as impaired endothelial function and altered fat metabolism, in response to physical activity (Green et al., 2017; Goldspink, 2005). These findings underscore the importance of tailoring interventions to the needs of hypertensive populations.

Several limitations warrant consideration. First, self-reported adherence may introduce variability. Objective monitoring using wearables could enhance adherence tracking and provide accurate intensity data (Xu et al., 2018). Second, the absence of dietary control limits conclusions about the contribution of nutrition to the observed outcomes. Future studies should incorporate dietary assessments to provide a more comprehensive understanding (Robinson et al., 2023). Third, the 12-week duration restricts insights into long-term sustainability; extended follow-up studies are essential to evaluate the persistence of these benefits (Vainshelboim et al., 2015). Lastly, the study's focus on hypertensive older men limits generalizability to women, younger individuals, and non-hypertensive populations (Araya-Ramírez et al., 2022).

Conclusions

This study demonstrates that a 12-week walking football program significantly improves key body composition metrics among hypertensive older men. Participants experienced reductions in BMI, BFP, WHR, and WHtR, alongside increases in LBM. These findings highlight the program's potential as an accessible physical activity intervention to support fat loss, lean mass preservation, and metabolic health improvements in this population.

However, the study's limitations—including the lack of adherence tracking, absence of heart rate monitoring, and short intervention duration—should be carefully considered when interpreting these results. Future studies should prioritize objective measures of exercise intensity, extended intervention periods, and diverse participant demographics to enhance the applicability and reliability of the findings. Specific areas for investigation include the program's impact on blood pressure regulation, cardiovascular function, and long-term adherence in different settings and populations (Collado-Mateo et al., 2021).

Healthcare practitioners are encouraged to consider walking football as part of personalized interventions for hypertensive older adults, particularly in community or clinical contexts where structured physical activity programs are feasible. By focusing on body composition improvements and their associated health benefits, walking football may serve as a valuable component of strategies aimed at reducing chronic disease risks and improving quality of life among older adults.

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