Research Article

High-Intensity Interval Training Versus Moderate-Intensity Continuous Training For Muscle Mass and Gait Speed in Older Adults With Sarcopenic Obesity: A Randomized Controlled Trial

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Abstract

Objective: To compare the effects of 12 weeks of high-intensity interval training and moderate-intensity continuous training, matched for total workload, on appendicular skeletal muscle mass and gait speed in older adults with sarcopenic obesity.

Methods: Single-centre, two-arm, parallel-group randomized controlled trial with blinded outcome assessors. Adults aged 60 years or older with sarcopenic obesity were randomly allocated to high-intensity interval training (n = 20) or moderate-intensity continuous training (n = 20), performed under supervision three times per week for 12 weeks. The primary outcomes were changes in appendicular skeletal muscle mass, measured by bioelectrical impedance analysis, and usual gait speed over 4 metres. Secondary outcomes were handgrip strength and body fat percentage.

Results: Thirty-five participants completed the trial (17 high-intensity interval training, 18 moderate-intensity continuous training). Appendicular skeletal muscle mass increased more with high-intensity interval training than with moderate-intensity continuous training (0.70 kg versus 0.11 kg; $p < 0.001$). Gait speed improved in both groups, with a larger gain after high-intensity interval training (0.13 m/s versus 0.04 m/s; $p < 0.001$). Gains in handgrip strength (2.28 kg versus 1.07 kg; $p = 0.005$) and reductions in body fat percentage (2.52 versus 1.31 percentage points; $p = 0.002$) also favoured high-intensity interval training.

Conclusion: Twelve weeks of supervised high-intensity interval training improved muscle mass, gait speed, muscle strength and body composition more than workload-matched moderate-intensity continuous training in older adults with sarcopenic obesity. Larger multicentre trials are needed to confirm these findings.

Keywords: Sarcopenia; Obesity; High-Intensity Interval Training; Exercise Therapy; Walking Speed; Aged.

Introduction

Sarcopenic obesity (SO) refers to the accumulation of body fat combined with the loss of muscle mass and quality.[1] SO is prevalent in the general population and is associated with cardiometabolic conditions, disability and loss of independence. Even in the absence of SO, the presence of either obesity or sarcopenia increases the risk of adverse health outcomes. Muscle quality is compromised with age as a result of the deposition of fat and connective tissue in and around the muscle, together with chronic inflammation and insulin resistance. These changes further amplify muscle protein breakdown. Thus, the goal of treatment is to increase muscle mass while decreasing fat mass.[2]

The treatment of sarcopenia involves regular resistance training to promote hypertrophy, as well as regular aerobic exercise.[3] Resistance training has been considered first-line treatment. Depending on patient preference and tolerance, both moderate-intensity and vigorous-intensity interval training have similar effects on muscle mass, muscle function and cardiorespiratory health. One study found that a high-intensity interval training (HIIT) programme composed of three 20-minute sessions per week over 12 weeks improved cardiorespiratory health, skeletal muscle mass and function in postmenopausal women.[4-6] HIIT can also stimulate muscle protein synthesis more than moderate-intensity continuous training (MICT).[7,8] Improvements in gait speed are thought to be primarily due to improvements in lower-body muscle strength and/or function.[9] The majority of studies supporting the use of exercise to treat sarcopenia are small, of low to moderate quality, and do not compare one type of exercise with another.

This study aimed to evaluate the effect of 12 weeks of HIIT or MICT, matched for total workload, on muscle mass and gait speed in individuals aged 60 years and older with SO.

Methods

Trial design and oversight

This was a single-centre, two-arm, parallel-group randomized controlled trial with blinded assessors and 1:1 allocation. All participants gave written informed consent and underwent a cardiology assessment prior to testing.

Participants

Participants were aged 60 years and older, with a body mass index (BMI) of 30 kg/m² or greater, or body fat of 35% or more in men and 42% or more in women. Participants had low muscle mass assessed by bioimpedance (ASM/height² less than 7 kg/m² in men and 5.5 kg/m² in women), and either low muscle strength (handgrip less than 27 kg in men and 16 kg in women) or slow gait. Participants were able to walk 10 metres and had no contraindications to exercise.[11,12] Exclusion criteria were unstable cardiovascular disease, uncontrolled hypertension (systolic/diastolic >180/110 mmHg), recent myocardial infarction or stroke, severe arthritis or neurological disease, cognitive impairment (Montreal Cognitive Assessment score less than 18) or a pacemaker. Participants had not been exercising under the direction of a physiotherapist or exercising regularly in the previous 3 months, and were not taking weight-loss drugs or anabolic therapy.

Randomization and blinding

Participants were randomly allocated to one of the two groups using computer-generated permuted blocks (sizes 4 and 6), stratified by sex. The allocation sequence was concealed in sequentially numbered, opaque, sealed envelopes by a staff member who did not participate in assessment. The envelopes were opened after the baseline assessment. Participants and trainers were not blinded to group assignment; the assessors and the statistician were blinded.

Interventions

Training was conducted three times a week for 12 weeks under the supervision of a physiotherapist. The HIIT and MICT groups used the same equipment (treadmill/cycle ergometer), and both groups trained for the same total workload and duration. Each session began and ended with 5 minutes of low-intensity exercise. The HIIT group performed 4 × 4-minute bouts at 80–90% of maximum heart rate, separated by 3 minutes of active recovery at 50–60% of maximum heart rate. The MICT group trained continuously at 60–70% of maximum heart rate for 30–40 minutes. In both groups, the training load was progressively adjusted to keep heart rate within the target range, and training was stopped if safety limits were reached. Both groups received nutritional education to increase protein intake to 1.0–1.2 g/kg of body weight per day and to reduce sedentary behaviour.

Outcomes

The primary outcomes were the changes from baseline to week 12 in appendicular skeletal muscle mass (ASM; kg) and usual gait speed (m/s). ASM was assessed by segmental multi-frequency bioelectrical impedance analysis (BIA) using a validated device.[13] Gait speed was assessed by having participants walk at their usual pace over 4 metres; the faster of two trials was used. BIA was performed after an 8–12-hour overnight fast, with an empty bladder, and at least 12 hours after the last strenuous activity. The same protocol, equipment and personnel were used at both assessments. A change of 0.1 m/s in gait speed was considered clinically relevant.[14]

Secondary outcomes were dominant handgrip strength (kg), assessed with a hand dynamometer; body fat (%), assessed by BIA; and the proportion of participants who increased their gait speed by at least 0.1 m/s. Reasons for withdrawal were documented.

Sample size

Twenty participants per group were targeted because of pragmatic constraints. This sample was sufficient to detect a large between-group difference ($\alpha = 0.05$, power = 0.80); the study was therefore considered exploratory.

Statistical analysis

Data were analysed using SPSS. Continuous data are expressed as mean ± standard deviation. Baseline characteristics were compared using the independent-samples t-test and the chi-square test. Within-group change from baseline was analysed using paired-samples t-tests, and between-group differences in change from baseline to week 12 were analysed using the independent-samples t-test. Normality was assessed with the

Shapiro–Wilk test, and the Mann–Whitney U test was used for non-normally distributed data (change in handgrip strength in the MICT group). A p value of less than 0.05 was considered statistically significant.

Results

Participants

Forty participants were randomized, 20 to each group (Figure 1). Five participants (12.5%) did not complete the 12-week programme: three in the HIIT group (personal reasons at week 4, knee pain at week 6 and loss to follow-up at week 8) and two in the MICT group (relocation at week 3 and illness unrelated to the study at week 7). The analysis was therefore performed on 17 participants in the HIIT group and 18 in the MICT group. At randomization, the groups were comparable on all measured variables except BMI, which was lower in the HIIT group than in the MICT group (33.3 ± 2.0 versus 35.0 ± 2.1 kg/m²; p = 0.018) (Table 1).

Table 1. Baseline characteristics of all randomized participants (mean ± SD).

Variable	HIIT (n = 20)	MICT (n = 20)	t / χ^2	p value
Age (years)	69.2 ± 4.8	70.8 ± 4.8	t = −1.05	0.301
Sex, women/men (n)	10/10	10/10	χ^2 = 0.00	1.000
Height (cm)	162.3 ± 7.5	161.6 ± 7.3	t = 0.30	0.766
Weight (kg)	88.0 ± 9.5	91.5 ± 10.7	t = −1.11	0.274
BMI (kg/m²)	33.3 ± 2.0	35.0 ± 2.1	t = −2.48	0.018
ASM (kg)	15.06 ± 2.69	15.12 ± 2.72	t = −0.08	0.940
Gait speed (m/s)	0.80 ± 0.05	0.82 ± 0.06	t = −1.25	0.219
Handgrip strength (kg)	18.5 ± 5.0	19.0 ± 5.2	t = −0.30	0.767
Body fat (%)	41.8 ± 4.2	41.9 ± 4.4	t = −0.08	0.939

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; ASM: appendicular skeletal muscle mass; BMI: body mass index; SD: standard deviation. Independent-samples t-test; chi-square test for sex.

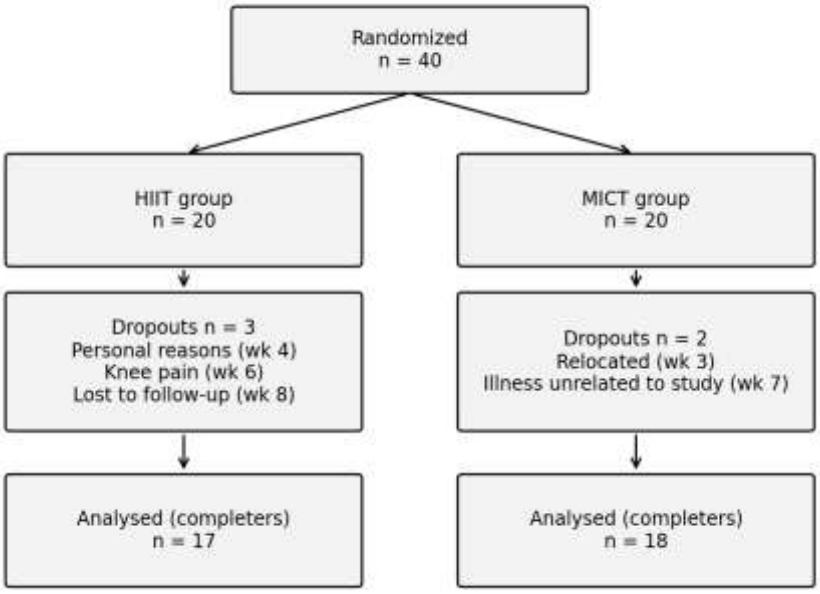


Figure 1. Flow of participants through the trial. HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; wk: week.

Primary outcomes

In the HIIT group, ASM increased significantly (15.24 ± 2.67 kg to 15.94 ± 2.71 kg; +0.70 ± 0.36 kg; paired t = 8.04, p < 0.001), whereas there was no significant change in the MICT group (15.06 ± 2.49 kg to 15.17 ± 2.41 kg; +0.11 ± 0.41 kg; t = 1.14, p = 0.271) (Table 2). The between-group difference in change was significant (t = 4.48, p < 0.001; Table 3).

Gait speed improved in both groups. In the HIIT group, gait speed increased from 0.81 ± 0.06 m/s to 0.93 ± 0.07 m/s (+0.13 ± 0.06 m/s; t = 8.35, p < 0.001), and in the MICT group from 0.82 ± 0.06 m/s to 0.86 ± 0.07 m/s (+0.04 ± 0.04 m/s; t = 4.35, p < 0.001). The improvement was significantly greater with HIIT (t = 4.81, p < 0.001; Table 3).

A clinically meaningful improvement in gait speed (an increase of at least 0.10 m/s) was achieved by 13 of 17 participants in the HIIT group and 2 of 18 participants in the MICT group.

Table 2. Baseline values, week-12 values and within-group change in participants who completed the 12-week programme (mean ± SD).

Outcome	Group	Baseline	Week 12	Change	Paired t	p
ASM (kg)	HIIT (n = 17)	15.24 ± 2.67	15.94 ± 2.71	+0.70 ± 0.36	8.04	< 0.001
	MICT (n = 18)	15.06 ± 2.49	15.17 ± 2.41	+0.11 ± 0.41	1.14	0.271
Gait speed (m/s)	HIIT	0.81 ± 0.06	0.93 ± 0.07	+0.13 ± 0.06	8.35	< 0.001
	MICT	0.82 ± 0.06	0.86 ± 0.07	+0.04 ± 0.04	4.35	< 0.001
Grip strength (kg)	HIIT	18.65 ± 5.05	20.92 ± 5.05	+2.28 ± 0.87	10.74	< 0.001
	MICT	18.99 ± 5.18	20.06 ± 5.41	+1.07 ± 1.15	3.93	0.001
Body fat (%)	HIIT	41.61 ± 4.14	39.09 ± 4.33	−2.52 ± 0.88	−11.85	< 0.001
	MICT	42.18 ± 4.06	40.88 ± 3.68	−1.31 ± 1.24	−4.47	< 0.001

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; ASM: appendicular skeletal muscle mass; BMI: body mass index; SD: standard deviation. Paired t-test within groups (df = 16 for HIIT, 17 for MICT).

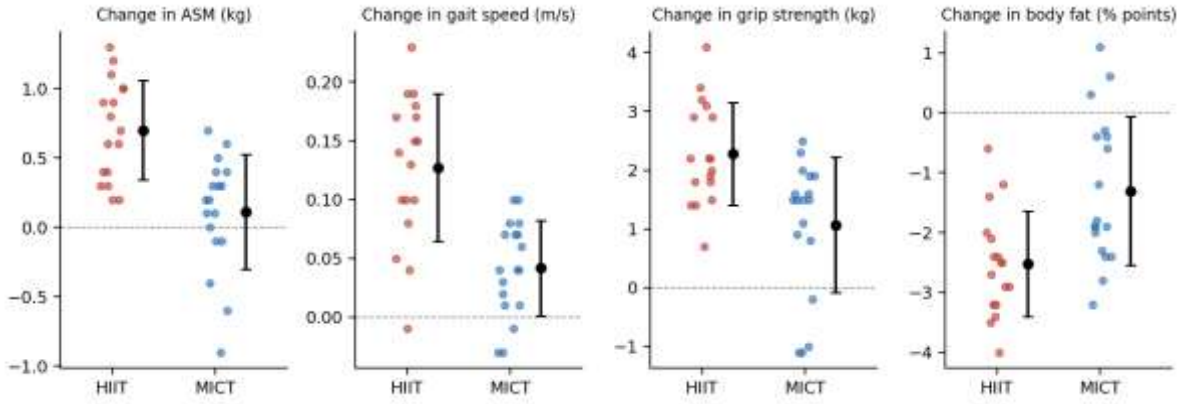


Figure 2. Individual changes from baseline to week 12 in participants who completed the programme, by group. Coloured dots represent individual participants; the black marker and bars show mean ± SD. ASM: appendicular skeletal muscle mass; HIIT: high-intensity interval training; MICT: moderate-intensity continuous training.

Secondary outcomes

Handgrip strength improved by 2.28 kg in the HIIT group and 1.07 kg in the MICT group. Because the change in the MICT group was not normally distributed (Shapiro–Wilk p = 0.006), the Mann–Whitney U test was used (U = 238.5, p = 0.005). Body fat decreased by 2.52 ± 0.88 percentage points in the HIIT group and 1.31 ± 1.24 percentage points in the MICT group (t = −3.34, p = 0.002) (Table 3).

Table 3. Between-group comparison of change from baseline to week 12 (mean ± SD).

Outcome	HIIT change (n = 17)	MICT change (n = 18)	t value	p value
ASM (kg)	+0.70 ± 0.36	+0.11 ± 0.41	4.48	< 0.001
Gait speed (m/s)	+0.13 ± 0.06	+0.04 ± 0.04	4.81	< 0.001
Grip strength (kg)	+2.28 ± 0.87	+1.07 ± 1.15	—	0.005*
Body fat (%)	−2.52 ± 0.88	−1.31 ± 1.24	−3.34	0.002

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; ASM: appendicular skeletal muscle mass; BMI: body mass index; SD: standard deviation. Independent-samples t-test unless indicated. *Mann–Whitney U test (U = 238.5), used because the change in the MICT group was not normally distributed.

Dropouts and safety

The dropout rate was 15% in the HIIT group and 10% in the MICT group. One participant in the HIIT group withdrew because of knee pain; all other withdrawals were unrelated to the study.

Discussion

The results of this randomized controlled trial suggest that, in older adults with sarcopenic obesity, 12 weeks of HIIT leads to greater improvements in muscle mass, gait speed, grip strength and body fat than MICT of equal workload. Improvements in both primary outcomes were large and highly significant, supporting the hypothesis that HIIT is superior to MICT for at least one of the primary outcomes.

The increase in ASM of 0.70 kg with HIIT, compared with 0.11 kg with MICT, provides evidence that muscle mass can be increased in older adults through exercise. A recent meta-analysis of exercise interventions for adults with stage I SO reported no significant changes in appendicular muscle mass but improvements in physical function.[6] For muscle mass, therefore, exercise of a type similar to HIIT may offer additional benefit. Our findings are in line with a recent trial of 57 participants with low relative lean mass that reported significant increases in lean mass with high-intensity interval training and high-intensity functional interval training.[15]

Gait speed increased in both groups; however, the increase exceeded 0.10 m/s in the HIIT group and was below 0.10 m/s in the MICT group, so only the change with HIIT was clinically meaningful. About 78% of the HIIT group and 11% of the MICT group achieved a clinically meaningful increase in gait speed. Because slow gait speed is associated with disability, frailty and death,[4] the changes observed in the HIIT group are of greater clinical relevance.

Changes in body composition and muscle strength were also greater in the HIIT group than in the MICT group. The combination of fat loss and muscle gain is the ideal outcome for a person undergoing weight reduction. The main set in HIIT lasted 16 minutes, shorter than the aerobic portion of the MICT sessions, indicating that HIIT is time-efficient.[16] A previous 12-week HIIT programme likewise improved gait speed in older adults, with better results than continuous training.[9]

Strengths and limitations

The strengths of the study include randomization stratified by sex, blinded assessment of the primary outcomes, matched total training work in both groups, identical dietary instructions to both groups, and the use of gait speed as a primary outcome.

The study also had several limitations. First, it was exploratory, being single-centre with a small sample. Second. The withdrawal of 12.5% of participants may have introduced attrition bias. Finally, ASM was estimated by BIA; dual-energy X-ray absorptiometry (DXA) or cross-sectional imaging would provide more precise estimates of muscle mass.

Conclusion

Twelve weeks of supervised HIIT was more beneficial than MICT for improving appendicular muscle mass, gait speed, handgrip strength and body composition in older adults with sarcopenic obesity. These findings support the use of HIIT to improve health and body composition in this population. Larger, longer-term studies using DXA to evaluate muscle mass, and studies that include resistance training, are warranted to corroborate these findings.

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