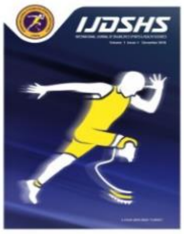

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RESEARCH ARTICLE

Acute Effects of High-intensity Circuit Training Using Body Weight on Body Composition Indices in Sedentary Collegiate Females

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Abstract
High-intensity circuit training (HICT) has become increasingly popular for enhancing health and fitness. However, limited research exists on the effects of high-intensity circuit training using body weight (HICTBW) on body composition in sedentary young adults. This study aimed to explore the impact of a 4-week HICTBW program on body composition in sedentary collegiate females. A randomized controlled trial design was employed. Twenty sedentary collegiate females were randomly assigned to either a training group (n=10), which participated in a 4-week HICTBW program, or a control group (n=10), which did not engage in any training. Body composition was assessed using bioelectrical impedance analysis (r = 0.642 to 0.78), measuring body fat percentage, fat mass, muscle mass, waist-to-hip ratio, and body mass index (BMI). Repeated measure ANOVA was used to compare between and within groups. Although no significant differences in body composition variables were observed between pre- and post-training (p>0.05), slight positive changes were noted in all measured parameters. The lack of significant findings may be attributed to the short duration and frequency of the intervention. Future studies with extended training periods are recommended to better understand the potential impact of HICTBW on body composition in sedentary collegiate females. This research highlights the need for more comprehensive studies to validate the effectiveness of HICTBW in improving body composition among this population.

Keywords
HICT, HICTBW, Body Composition, Sedentary, Training

INTRODUCTION

Sedentary behavior has become a pressing public health concern, particularly among individuals with low physical demands, such as those engaged in intensive study (Aktas et al., 2016; Lau et al., 2021). Defined as activities with minimal energy expenditure and insufficient weekly exercise time (less than 150 minutes), sedentary behavior is strongly associated with cardiometabolic diseases, mortality, and reduced cardiorespiratory fitness (Garber et al., 2011; Rezende et al., 2014). Epidemiological and anthropological observations have indicated that women exhibit lower physical activity levels compared to men (Bowen et al., 2011), which correlates with increasing rates of cardiovascular disease in females (Maas & Appelman, 2010).

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Conversely, enhancing physical activity levels in women has been linked to improved health- related outcomes (Raberin et al., 2020).

Physical activity (PA), characterized by skeletal muscle contractions that elevate energy expenditure above resting metabolic rate, is well-established as a preventive measure against chronic diseases and for promoting physical well- being (Yamaner et al., 2024; Ajjimaporn et al., 2019). In contrast, physical inactivity, defined as failing to meet PA guidelines and engaging in sedentary behaviors with low energy expenditure, poses significant health risks and adverse outcomes, including declines in mental health and cognitive function (Ajjimaporn et al., 2019; Zhang et al., 2021). Consequently, physical inactivity and sedentary behaviors have emerged as notable risk factors, imposing a substantial burden on public health.

Of concern, physical inactivity is more prevalent among women, who exhibit higher rates of insufficient PA compared to men (Whiting et al., 2021). Young women face an elevated risk of being sedentary and physically inactive, leading to increased stress, anxiety, reduced cognitive function, and elevated all- cause mortality. This trend may persist with age, as physical inactivity becomes more pronounced among older women. To address this issue and foster improved health outcomes, the implementation of appropriate physical training intervention strategies is crucial in encouraging sedentary young females to adopt, sustain, and enhance their physical activity behaviors.

Recently, high-intensity circuit training (HICT) has gained popularity due to its time efficiency and practicality (Ajjimaporn et al., 2019; Sumpena & Sidik, 2017). HICT entails a combination of aerobic and resistance exercises, involving short high-intensity intervals interspersed with lower intensity recovery periods (Sumpena & Sidik, 2017). In healthy individuals, high-intensity circuit training using body weight (HICTBW) has demonstrated greater improvements in physical fitness within a shorter exercise duration (e.g., 7 minutes) compared to traditional HICT programs (Klika & Jordan, 2013). Studies (Ajjimaporn et al., 2019; Zhang et al., 2021) have shown the favorable effects of HICTBW on cardiopulmonary fitness in overweight middle-aged men and moderately fit women, respectively, with indications of gender-specific response to HICTBW training. Remarkably, HICT appears to offer superior benefits for cardiovascular, mental, and cognitive health compared to alternative training approaches.

Despite the promising results of HICTBW in various populations, there is a paucity of research investigating its effectiveness on body composition indices in sedentary young females. Most existing studies focus on cardiovascular and cognitive benefits, neglecting the critical aspect of body composition which is crucial for overall health and physical appearance. Moreover, the specific effects of short-term HICTBW interventions remain underexplored in this demographic, leaving a gap in the literature that needs addressing.

This study aims to evaluate the acute effects of a 4-week HICTBW intervention on body composition indices, including Body Mass Index (BMI), waist-to-hip ratio, fat percentage, fat mass, and lean mass, in sedentary collegiate females. By addressing this gap, the study seeks to provide insights into the effectiveness of short-term HICTBW programs in improving body composition among young women, ultimately contributing to better health and fitness strategies tailored for this vulnerable population.

MATERIALS AND METHODS

This research has met ethical rules. Research ethical approval was obtained from the UiTM Research Ethics Committee with project number REC/486/2023. A pre-test and post-test randomized design was used in this study in measuring the effects of HICTBW on all body composition indices among sedentary collegiate females.

Participants

This study was conducted following the approval of the research ethics committee at Universiti Teknologi MARA. Volunteer participants were recruited through public advertisements via local media. Inclusion criteria comprised individuals aged between 20 and 25 years, categorized as inactive (defined as engaging in less than 150 minutes of moderate-intensity exercise per week over the past six months), and classified as having a normal to overweight body mass index (BMI, $kg\cdot m^{-2}$) falling within the range of 18.5 to 25. To ensure eligibility, interested volunteers meeting the inclusion criteria were required to complete a short form of the International Physical Activity Questionnaire (IPAQ), with intraclass correlation coefficients (ICC) reported between 0.71 and 0.89

(Dinger et al., 2006), and a Physical Activity Readiness Questionnaire (PAR-Q) with reliability reported r = 0.99 (Jamnik et al., 2011). Smokers, alcoholics, diabetics, individuals with endocrine disorders, and those using oral contraceptive pills or prescribed medications known to affect body composition were excluded from the study.

Based on a within-subject correlation of 0.70 between pre- and post-intervention measures, a power of 0.80, and an effect size of 0.48 as derived from the primary outcome resulting from high-intensity interval training (Ajjimaporn et al., 2019), the sample size for the high-intensity interval training (HIIT) group was determined to be eight. After the screening phase, a total of 20 eligible participants as shown in Figure 1 were enrolled in the study and provided written informed consent. Subsequently, they were randomly assigned to either the training (TG) group (n = 10) or the control (CT) group (n = 10).

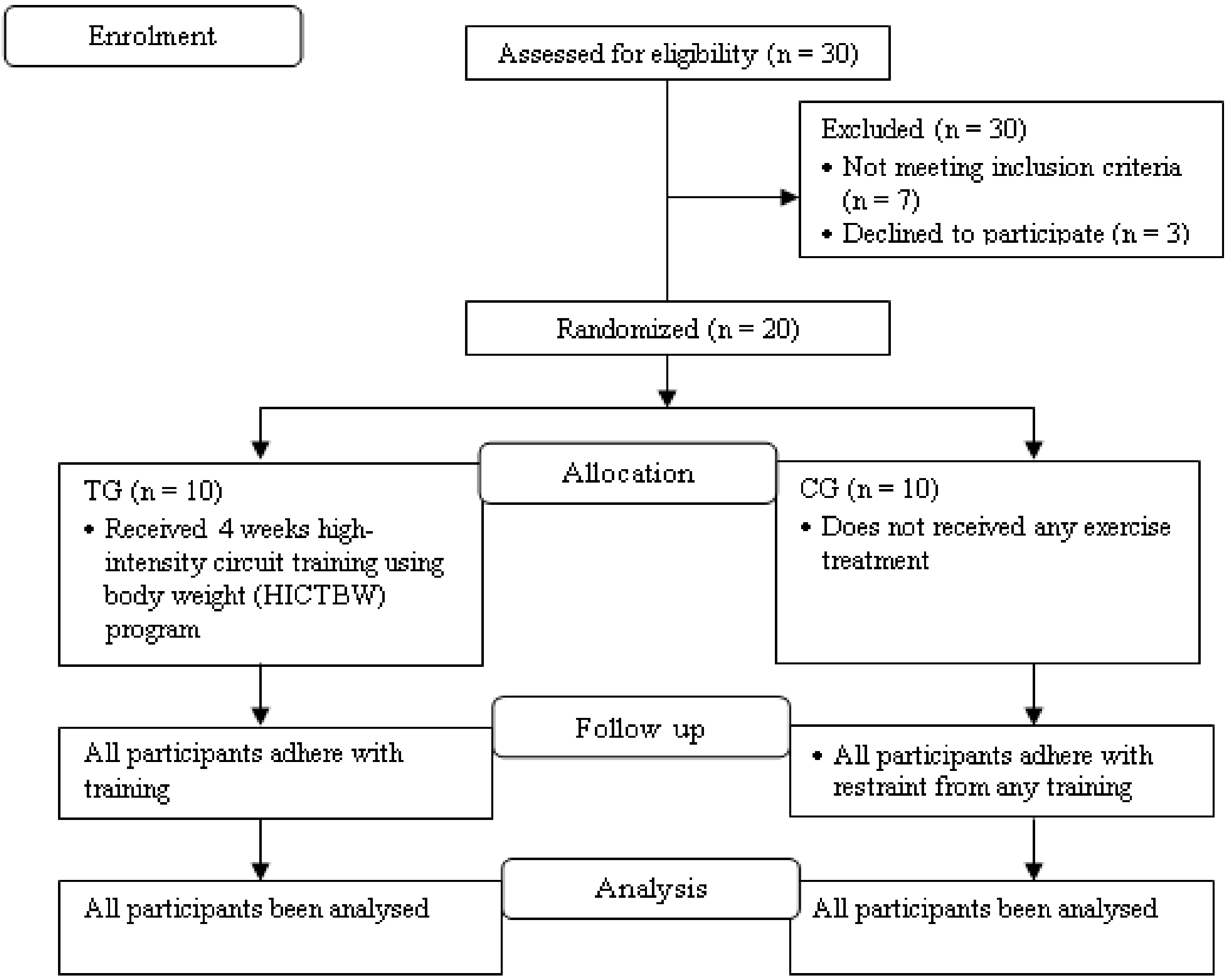

Figure 1. Participants flow char

Experimental Procedures

All participants in the TG group engaged in a four-week high-intensity circuit training using body weight (HICTBW) regimen, while the participants in the CT group did not partake in any exercise intervention. Prior to commencing the training intervention, a body composition analysis assessment was conducted, and the pretraining measurements were recorded within 48 to 144 hours preceding the training intervention. Subsequently, following the four-week training period, a post-training body composition analysis assessment was performed, with all post-training measurements obtained within 48 to 144 hours after the last training session. It is important to note that during the intervention, one participant voluntarily withdrew from the study due to injuries sustained, which were unrelated to the research procedures.

Testing Protocol

Anthropometric and body composition assessments were conducted with participants arriving at the laboratory in the morning. Height and weight measurements were obtained using standard methods, employing a stadiometer (Seca 220; Seca, Ltd, Hamburg, Germany) and an electronic scale (participants in light clothing and without footwear) to the nearest 0.1 cm and 0.1 kg, respectively. The body mass index (BMI) was calculated by dividing weight (kg) by height (m) squared. The waist-to-hip ratio was determined using the Seca 201 tape (Seca, Ltd, Hamburg, Germany) with a constant pulling tension. Trained personnel assessed body fat percentage, fat mass, and lean body mass using the multi- frequency bioelectrical impedance analysis, BodyStat QuadScan 4000 (Bodystat Ltd.; Isle of Man, UK), following the tetrapolar method as previously outlined by Sbrignadello et al. (Sbrignadello et al., 2022).

In the training (TG) group, participants underwent a high- intensity circuit training using body weight (HICTBW) program adapted from Klika and Jordan (Klika & Jordan, 2013), considered suitable for sedentary individuals to safely perform, and approved by two sports scientists. Following a standardized 5-minute warm-up period, participants completed 12 body weight exercises, each performed for 30 seconds with a 10- second rest interval (approximately 7.5 minutes per circuit). The exercises included step jack, wall-sit, wall push-up, sit- up hand reach, step-up onto aerobic step, half squats, triceps dip onto aerobics step, knee plank, hops, alternate lunges, plank with rotation, and knee side plank. After completing the body weight circuit, participants engaged in a 5-minute cool-down period. The training program consisted of three sessions per week over four weeks, with the volume progressively increasing from one circuit in the first week, to two circuits in the second and third weeks, and three circuits in the fourth week of training, respectively. Details of the total training duration and exercise intensities are presented in Table 1. The percentage of maximum heart rate (%HRmax) was calculated by dividing the maximal heart rate during exercise by the age-predicted maximal heart rate and then multiplying by 100. The exercise intensity levels based on %HRmax were categorized as very light (≤ 57), light (57-63), and moderate (64 – 76).

Statistical Analysis

Data analysis was conducted using IBM SPSS version 28.0 (IBM Corporation, Armonk, NY, USA). The results are presented as mean ± standard deviation (SD). The normality of the data was assessed using the Shapiro-Wilk test. Independent t-tests were utilized to analyze the differences in physical characteristics between the two groups at baseline. To assess the effects of the intervention on body composition measurements over time (0-week versus 4-week), comparisons between the training group (TG) and the control group (CT) were performed using repeated-measures ANOVA. The statistical significance level was set at $p < 0.05$.

Table 1. Detailed of a 4-Week HICTBW Program

Weeks	Circuit	Warm-up, min	Exercise Duration, min	Cool-Down, min	Total Training Duration, min	%HR max
1	1	5	7.5	5	17.5	60 (light)
2-3	2	5	15.5	5	35	66 (moderate)
4	3	5	23.5	5	52.5	68 (moderate)

RESULTS

At baseline, no statistically significant differences were observed in participant characteristics between the training group (TG) and control group (CT), as shown in Table 2 (p >0.05). Throughout the 4-week HICTBW program, no significant changes were detected in bodyweight, BMI, fat percentage, fat mass, muscle mass, or waist-to-hip ratio within either group, as evidenced by Figure 2 and analysis of two-way ANOVA results (p>0.05). Specifically, the training group showed bodyweight changes from 56.89±11.71 kg at baseline to 56.63±10.10 kg post-intervention, while the control group changed from 56.91±10.66 kg to 56.61±10.77 kg ($F(1,17) = 0.0000$, $p = 0.992$). Fat mass in the training group decreased slightly from 18.28±4.76 kg to 17.43±5.54 kg, and in the control group from 16.68±4.42 kg to 15.84±3.45 kg ($F(1,17) = 0.602$, $p = 0.449$). Muscle mass, BMI, and waist-to-hip ratio also showed no significant changes in both groups.

Table 2. Participants Characteristics of Training (TG) and Control (CT) Groups

Parameters	TG	CT	*p* value
Age	22.30±0.949	22.89±1.53	0.323
Weight (kg)	56.89±11.71	56.91±10.66	0.998
Body Mass Index (kg/m2)	22.77±	22.66±	0.946
Fat percentage	31.81±4.37	29.34±3.21	0.183
Fat Mass	18.28±4.76	16.68±4.42	0.459

Training (TG); Control (CT)

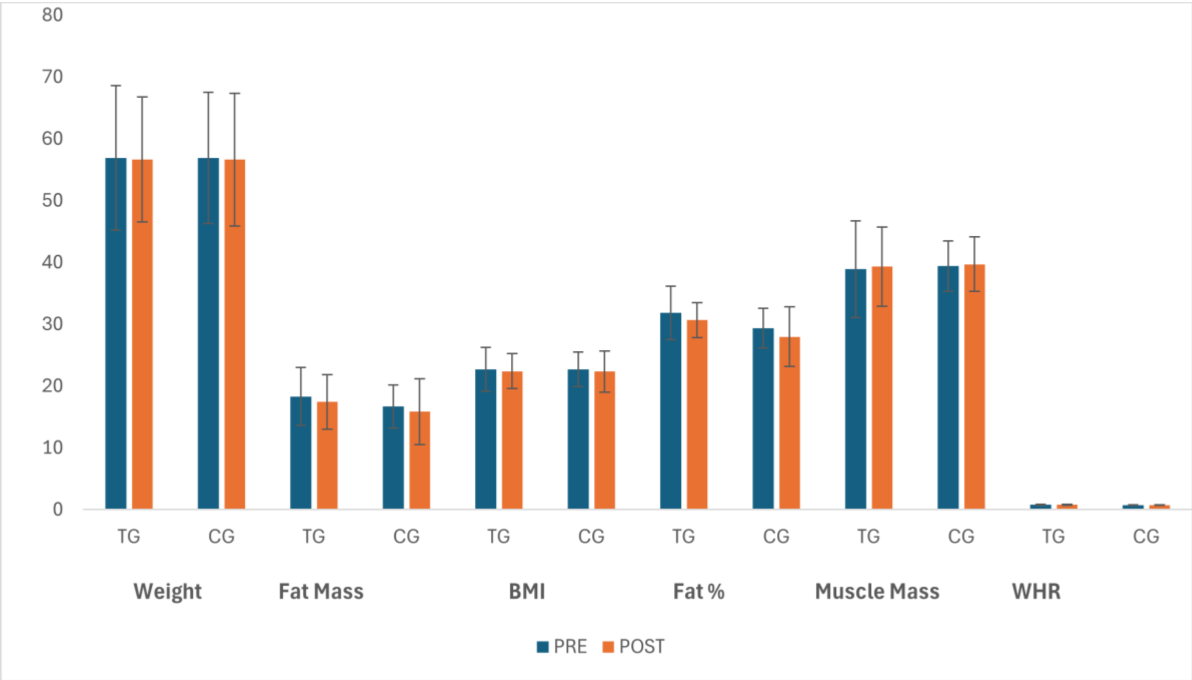

Figure 2. Differences between training groups in weight, fat mass, bmı, fat percentage, muscle mass, and waist to hip ratio before and after hıctbw exercises

DISCUSSION

The outcomes of the current study revealed that a 4-week HICTBW program had no significant effect on body weight and body composition in sedentary collegiate females. Despite observing slight changes in participants' body weights following the 4-week intervention, it is essential to recognize that energy consumption was not controlled during the experimental testing, as all participants were instructed to maintain their current dietary habits. Consequently, the presence of uncontrolled dietary factors may have influenced the observed similarities in body mass measurements after the 4-week training period, potentially masking any potential weight loss (Curioni & Lourenço, 2005; Atasever & Kıyıcı, 2023).

Moreover, we also investigated the impact of the 4-week HICTBW program on skeletal muscle mass and body fat parameters, specifically body fat mass and body fat percentage, and found no significant changes. Interestingly, these results contrast with the findings reported Mattar et al., (2017), who demonstrated that HICTBW program training led to a decrease in body fat percentage and body fat mass in healthy young participants during the initial 3 to 6 weeks of training. The discrepancy in outcomes may be attributed to several factors, including differences in the frequency and duration of training sessions (Friedrich, 2014; Parry & Straker, 2013), as well as variations in the intensity of the training program (Garber et al., 2011).

It is worth noting that the study conducted by Mattar et al. (Mattar et al., 2017) involved a training frequency of 7 days per week over a 6-week duration, while the present investigation implemented a training frequency of 3 days per week for 4 weeks. The dissimilarity in training intensity and duration may underscore the importance of considering HICTBW training intensity as a critical factor in designing exercise programs aimed at influencing body composition in young adult, sedentary females. Future research exploring the impact of varying training intensities and durations within the HICTBW framework could provide valuable insights into optimizing exercise programs for body composition alterations in this specific population. Furthermore, it would be beneficial to conduct studies incorporating controlled dietary interventions to better elucidate the independent effects of exercise and nutrition on body composition outcomes in sedentary collegiate females.

Limitations in this study include the large sample size, this study had a relatively small sample size of 20 participants. Increasing the sample size increases the statistical power and generalizability of the findings. Previous studies have shown that a larger sample size is more likely to detect a significant effect. Including a control group with dietary modification, this study found that a 4-week HICTBW program resulted in no significant changes in body composition or weight loss among sedentary college women who maintained their dietary habits. Including a control group undergoing dietary modifications will help determine the independent effects of the exercise program on body composition. Have a longer intervention period; this study implemented a 4-week intervention period. Extending the duration of the intervention allows for more substantial changes in body composition. Previous research has shown that long-term interventions are more effective in achieving significant weight loss and changes in body composition. Assess adherence to the training program: Monitoring and reporting on participants' adherence to the training program will provide important information about the eligibility and compliance of the intervention. This information can help interpret the results and determine program effectiveness. Include goal measures of physical activity and sedentary behavior. This study relied on self-reported measures of physical activity and sedentary behavior; incorporating objective measures, such as accelerometers or pedometers, would provide more accurate and reliable data on participants' activity levels and sedentary behavior, and stratifying the analysis by ethnicity, this study involved a multi-ethnic Asian population. Stratification analysis by ethnicity can reveal potential differences in physical activity and sedentary behavior patterns, as well as intervention effectiveness, among different ethnic groups.

Conclusion

In conclusion, the findings of this study suggest that the implementation of a 4-week HICTBW program, consisting of 12 poses per circuit performed three times weekly for 4 weeks, did not result in significant changes in body composition or lead to weight loss among sedentary collegiate females who maintained their existing dietary habits throughout the intervention period. Despite the program's duration and frequency, the lack of observed effects on body composition and weight loss implies that additional factors, such as dietary modifications or alterations in the intensity of the training program, may be necessary to achieve meaningful changes in these parameters in this specific group of sedentary collegiate females.

Conflict of Interest

We declare that the article we have written does not involve any conflict of interest.

Ethics Statement

This research has met ethical rules. Research ethical approval was obtained from the UiTM Research Ethics Committee with project number REC/486/2023.

Author Contributions

Study design, PANKO, AMN and WAMWP; Data collection, NAAMR and MS; Statistical analysis, SMSMP; Data interpretation, MNM and RNJRH; Literature search, MFA and NAAK. All authors have read and approved the published version of the manuscript.

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