THE EFFECTIVENESS OF LOW-IMPACT RESISTANCE CIRCUIT TRAINING IN IMPROVING HEALTH OUTCOMES FOR FEMALE UNIVERSITY STUDENTS WITH HIGH BMI

Author(s) / Szerző(k):
Pham Tam Dan
University of Debrecen

E-mail:
phamtamdan18112000@gmail.com

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Absztrakt

AZ ALACSONY TERHELÉSŰ ELLENÁLLÁSOS KÖREDZÉS HATÉKONYSÁGA A MAGAS BMI-VEL RENDELKEZŐ EGYETEMI HALLGATÓ NŐK EGÉSZSÉGI ÁLLAPOTÁNAK JAVÍTÁSÁBAN

Az elhízás egyre növekvő egészségügyi kihívást jelent a női egyetemi hallgatók körében, amit gyakran tovább súlyosbítanak az egyetemi nyomás és az ülő életmód. A nagy terhelésű edzések ijesztőek lehetnek a túlsúllyal küzdők számára az ízületi fájdalmak és a csökkent motiváció miatt. Az alacsony terhelésű ellenállásos köredzés (Low-Impact Resistance Circuit Training, LI-RCT) ígéretes megoldást kínál, mivel ötvözi az erőnléti és a kardió gyakorlatokat, miközben csökkenti az ízületek terhelését.

A vizsgálatban 23 résztvevő vett részt, akiket két csoportra osztottak: LI-RCT csoport (n=12) és kontrollcsoport (CG) (n=11). A mérések antropometriai adatokat (testtömeg, BMI, derékkörfogat, WHR), fizikai fittségmutatókat (nyugalmi pulzusszám – RHR, vérnyomás, VO2max) és életminőség-mutatókat (OWLQOL, WRSM, PACES) tartalmaztak.

Az eredmények jelentős javulást mutattak az LI-RCT csoport esetében a kontrollcsoporthoz képest: csökkent a testtömeg (p<0,001), BMI (p<0,001), derékkörfogat (p<0,01) és WHR (p<0,01), miközben nőtt a VO2max (p<0,001) és csökkent az RHR (p<0,001). Az életminőség is jelentős javulást mutatott: magasabb OWLQOL pontszám (p<0,001), alacsonyabb WRSM (p<0,001) és magasabb PACES érték (p<0,01). Ezek az eredmények alátámasztják, hogy az LI-RCT hatékony módszer az egészségi állapot, fittség és jóllét javítására ebben a célcsoportban.

Kulcsszavak: egészségfejlesztés, alacsony terhelésű köredzés, női egyetemi hallgatók
Diszciplinák: egészségtudomány, sporttudomány

Abstract

Obesity is a growing health challenge for female university students, often compounded by academic pressures and sedentary routines. High-impact workouts can be daunting for individuals with excess weight due to joint discomfort and low motivation. Low-impact resistance circuit training (LI-RCT) presents a promising solution by combining strength and cardio exercises while easing joint stress.

This study involved 23 participants, divided into a LI-RCT group (n=12) and a control group (CG) (n=11). Measurements included anthropometric data (body weight, BMI, waist circumference, WHR), physical fitness (RHR, blood pressure, VO2max), and quality-of-life metrics (OWLQOL, WRSM, PACES).

Results revealed significant improvements for the LI-RCT group compared to the control group: reduced body weight (p<0.001), BMI (p<0.001), WC (p<0.01), and WHR (p<0.01), alongside enhanced VO2max (p<0.001) and lower RHR (p<0.001). Quality of life also saw marked enhancements, with higher OWLQOL scores (p<0.001), lower WRSM (p<0.001), and increased PACES (p<0.01). These findings highlight LI-RCT as an effective strategy to improve health, fitness, and well-being in this demographic.

Keywords: health promotion, low-impact circuit training, female university students
Disciplines: Health Science, Sport Science

The global obesity crisis: Rising prevalence, health impacts, and special concerns for female university students

Obesity has emerged as one of the most pressing global health challenges, with particularly alarming trends observed among young adults and females. Recent epidemiological projections paint a concerning picture: by 2030, it is estimated that more than one billion people worldwide will be living with obesity (BMI ≥30 kg/m²), with the condition disproportionately affecting women, impacting approximately one in five females compared to one in seven males (Okunogbe et al., 2021). The economic implications of this health crisis are far-reaching and substantial, with a significant portion (32%) attributed to direct medical expenses, while the majority (68%) stems from indirect costs, including premature mortality, reduced workforce participation, and diminished productivity across various sectors of society (Okunogbe et al., 2021).

Female university students have been identified as a particularly vulnerable demographic in this context (Tauqeer et al., 2018). Current research reveals concerning statistics: approximately 24% of college students in the United States are classified as overweight, while an additional 16% meet the criteria for obesity (Orr et al., 2008). Multiple interconnected factors contribute to this elevated prevalence, including but not limited to inconsistent dietary patterns, emotional eating triggered by academic pressures, irregular meal scheduling, increased alcohol consumption, and limited nutritional awareness (Castro et al., 2020; Lee et al., 2023; Telleria-Aramburu & Arroyo-Izaga, 2022). The contemporary university environment inadvertently promotes sedentary behaviors through extended periods of physical inactivity during lectures and study sessions, while simultaneously witnessing a notable decline in organized sports participation compared to secondary education years (Deliens et al., 2015).

The health ramifications of obesity are both extensive and severe, impacting multiple body systems and physiological processes. Physical manifestations encompass a broad spectrum of serious conditions, including cardiovascular diseases, type 2 diabetes, various forms of cancer, and musculoskeletal disorders (Csige et al., 2018; Wilcox et al., 2024). The underlying mechanisms linking obesity to these health conditions are intricate and multifaceted, involving complex pathways such as systemic chronic inflammation, significant hormonal imbalances, and increased mechanical stress on weight-bearing joints (Guha et al., 2021). Women, in particular, face additional health challenges through various reproductive health complications, including menstrual cycle irregularities, fertility issues, and increased risks during pregnancy and childbirth (Chin et al., 2014).

The impact of obesity extends far beyond physical health, profoundly affecting psychological well-being and social functioning. Individuals living with obesity frequently encounter challenges related to body image perception, diminished self-esteem, and an elevated risk of developing mental health conditions such as clinical anxiety and depression (Weinberger & Luck-Sikorski, 2021). The pervasive nature of weight stigma and discrimination manifests across various life domains, including healthcare settings, educational institutions, and professional environments, often resulting in social isolation, reduced career opportunities, and limited social engagement (Brewis et al., 2018; Sarwer & Grilo, 2020).

These interconnected challenges create a complex and self-reinforcing cycle where physical and psychological factors continuously interact and amplify each other, highlighting the critical importance of developing and implementing effective, comprehensive intervention strategies to address this multifaceted health issue.

Limitations of traditional exercise approaches in obesity management

Exercise interventions for obesity management face significant challenges in their conventional approaches. Traditional weight loss programs encounter two primary obstacles when working with individuals with obesity: excessive joint stress and difficulty maintaining adequate cardiovascular endurance during exercise (Higgins & Higgins, 2016). These barriers significantly affect exercise adherence and effectiveness, potentially undermining weight management success.

Current obesity management typically employs three main exercise approaches: Aerobic Exercise (AE), High-Intensity Interval Training (HIIT), and Progressive Resistance Exercise (RE). Each method, while beneficial, has specific limitations. AE effectively improves cardiovascular health and promotes weight loss but can cause joint stress and mobility issues, particularly in high-impact activities (Lemes et al., 2018; Thorogood et al., 2011). HIIT offers time-efficient workouts but proves physically demanding and often intimidating for exercise newcomers (Coates et al., 2023; Marriott et al., 2021). RE enhances muscle mass and metabolism but lacks comprehensive fitness benefits when used alone (see: Strasser & Schobersberger, 2011).

The limitations of these traditional approaches highlight the need for more adaptable and comprehensive exercise solutions. While combining different exercise types can address various fitness aspects, the key challenge remains finding an approach that integrates these benefits while reducing barriers to participation and adherence. This recognition has led to increased interest in alternative exercise strategies that better serve individuals with obesity while maintaining effectiveness.

Low-impact resistance circuit training (LI-RCT): A tailored exercise approach for overweight and obese individuals

Given the challenges of traditional exercise interventions for individuals with obesity, there is a pressing need to develop and implement targeted strategies that address their unique physical limitations and health needs. One promising solution that has emerged is Low-Impact Resistance Circuit Training (LI-RCT), which combines strength training exercises performed in succession with minimal rest periods (J.-W. Kim et al., 2018).

LI-RCT is specifically designed to minimize joint stress while maximizing cardiovascular and muscular benefits (Buch et al., 2017). This approach involves modified bodyweight movements, resistance bands, and light dumbbells, all carefully selected to accommodate different fitness levels. The exercises target major muscle groups and are performed with high repetitions to maintain elevated heart rates throughout the session (J.-W. Kim et al., 2018).

Research has demonstrated that LI-RCT offers significant advantages over traditional exercise methods. Studies show it effectively reduces fat mass while simultaneously increasing muscle mass, improves cardiovascular fitness through enhanced aerobic performance and VO2 max, and helps regulate blood pressure (Buch et al., 2017; Hu et al., 2024; Schwingshackl et al., 2013). Notably, LI-RCT has proven more effective than conventional resistance training in reducing body weight and waist circumference, while outperforming aerobic exercise in building lean body mass (Marín-Pagán et al., 2020).

What makes LI-RCT particularly valuable for overweight and obese individuals is its adaptability and lower impact on joints. The program can be modified to accommodate individual needs and fitness levels, making it especially suitable for those who may struggle with traditional exercise modalities (Higgins & Higgins, 2016). Additionally, by placing less orthopedic stress on the legs compared to other aerobic activities, it provides a safer option for individuals at risk of joint-related injuries.

Given these comprehensive benefits and its proven effectiveness, LI-RCT presents itself as a promising intervention strategy for weight management in adults with overweight and obesity. This approach not only addresses the physical limitations often encountered in traditional exercise programs but also provides a sustainable path to improved fitness and health outcomes.

Methodology

Recruitment process

Recruitment for this study was conducted through a combination of social media platforms (Facebook and Instagram) and university bulletin boards, targeting our demographic of female university students.

To be eligible for participation in this study, individuals had to (1) be female aged 18-40, who were (2) actively enrolled in a university. Participants needed to have (3) a BMI between 25-39.9 kg/m² and (4) a WC greater than 80 cm. It was crucial that potential participants demonstrated (5) a willingness to fully engage in the study throughout its duration.

Certain factors excluded individuals from participating in the study. These included (1) engaging in regular exercise (more than 40 minutes/week) consistently over the past 3 months, having (2) medical conditions that restrict exercise, (3) current smoking habits, (4) pregnancy or planning to get pregnant, and (5) following a weight-loss diet at the time of recruitment. These exclusion criteria helped ensure the study's results were not influenced by external factors and maintain the safety of the participants.

Study design

The study recruitment process began with 37 individuals completing the initial recruitment form. Of these, 31 met the eligibility criteria and were then randomly assigned to either the control group (CG) or the LI-RCT group (LI-RCTG) with a ratio of 1:2 respectively to account for the drop-out in the exercise group, resulting in 11 in the CG and 20 in the LI-RCTG. After the intervention period, 12 participants from the LI-RCTG and 11 from the CG were included in the final analysis (Figure 1).

Outcome measures

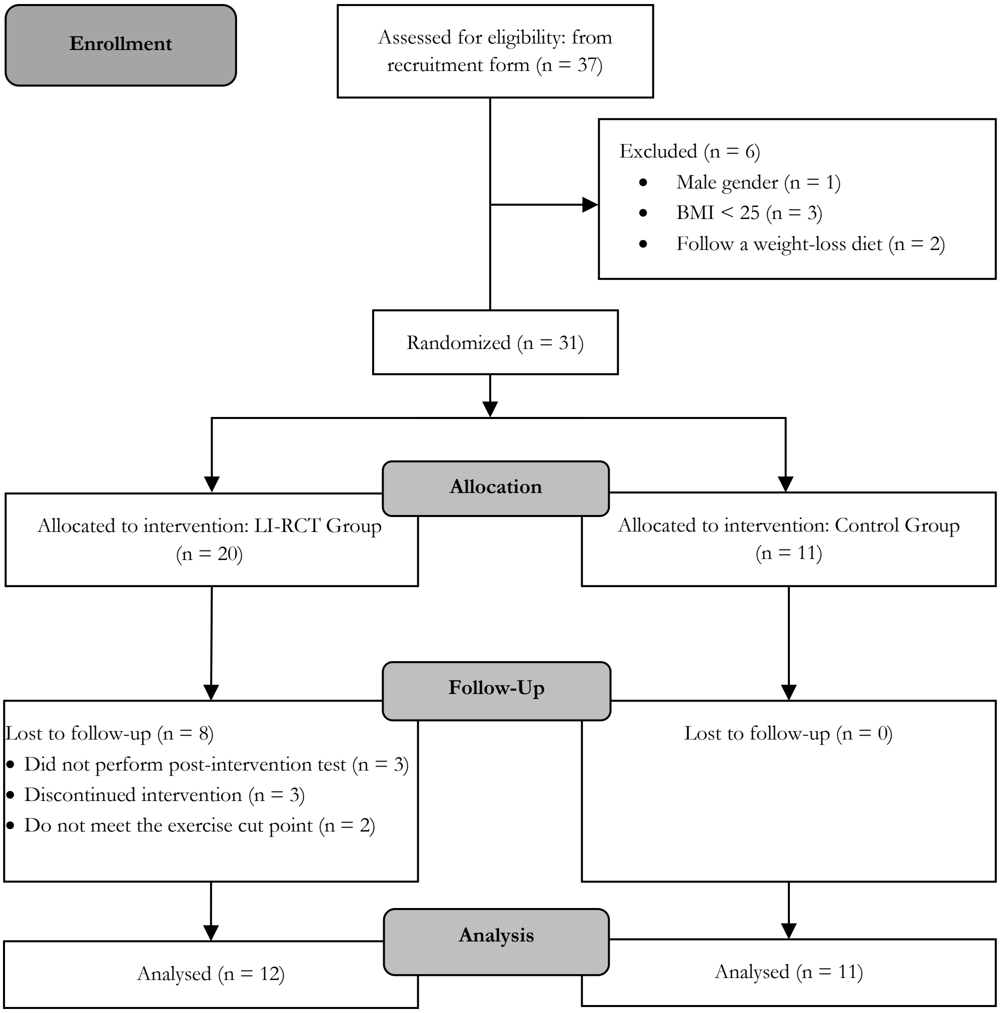
Prior to the start of the pre-measurement process, the participants were asked to carefully read and sign the consent forms. Anthropometric and physical fitness outcomes were measured in person at the Department of Physiotherapy, University of Debrecen. Participants were informed to arrive for pre- and post-intervention measurements between 8–10 AM on empty stomach and bladder. They were instructed to refrain from smoking, consuming caffeinated beverages, or exercising within 30 minutes prior to arrival. Comfortable, snug-fitting clothing and supportive footwear were required.

Anthropometric measurements

For body weight, the electronic digital scale was used and set to kilogram mode, with the digital LED readout displaying 000.0 before weighing. The participant stood at the center of the scale platform wearing minimal clothing. Weight was recorded in kilograms to the nearest tenth. Following the Third National Health and Nutrition Examination Survey (NHANES III) protocol, the participant stood upright against the vertical wall, weight evenly distributed on both feet. Heels were together, touching the wall base, with feet angled slightly outward at 60 degrees. The buttocks, scapulae, and head were in contact with the wall, arms hanging freely by the sides, palms facing the thighs. The participant inhaled deeply and stood fully erect without moving the heels (NHANES III, 1988). Height was recorded to the nearest 0.1 cm. BMI was calculated as weight (kg) divided by height squared (m^2), recorded to the nearest hundredth.

For waist circumference (WC) measurement as stated in NHANES III, 1988, the right iliac crest was palpated and marked with a horizontal line at the highest point. The participant's pants and underclothing were slightly lowered for direct palpation. The measuring tape was wrapped horizontally around the trunk at the marked level, ensuring it remained parallel to the floor and snug without compressing the skin. The measurement was taken during minimal respiration and recorded to the nearest 0.1 cm.

Figure 1: CONSORT flowchart showing the participants' enrollment process, allocation, follow-up, and analysis. Source: the Author



To measure hip circumference according to NHANES III, 1988, the participant stood erect with feet together and weight evenly distributed. The measuring tape was placed around the buttocks at the maximum extension point, ensuring it was horizontal to the floor. The zero end of the tape was held under the measurement value, snug but not tight. Hip circumference was recorded in centimeters to the nearest tenth. Waist-to-hip ratio (WHR) was calculated by dividing the WC by the hip circumference, recorded to the nearest hundredth.

Physical fitness measurements

Upon arrival, participants rested for 15 minutes. A pulse oximeter measured the resting heart rate (RHR) while the participant was seated. The RHR was measured three times, and the final RHR was calculated as the average of these measurements.

For the measurement of blood pressure, participants sat upright with feet flat on the floor and arm relaxed at heart level. An automatic, cuff-style, upper arm monitor is used to measure blood pressure. The cuff was placed above the elbow bend and wrapped against bare skin. Two measurements were taken with a one-minute interval in between. The final blood pressure reading was the average of these two measurements.

The YMCA 3-minute step test was conducted with the participants stepped up and down on a 30 cm box for 3 minutes. A metronome set at 96 beats per minute guided the stepping frequency, following a cadence of "up, up, down, down." At the 3-minute mark, participants immediately stopped, sat down, and their heart rate was recorded using a pulse oximeter. According to Kieu et al., 2020, the estimated VO_2 max equation developed by the Korean Institute of Sport Science had proven to be a reliable, more cost-effective and time-efficient alternative for assessing VO_2max than using treadmills or cycle ergometer. The heart rates obtained from the YMCA 3-minute Step Test were used to estimate the VO_2max using the following equation for female: $VO_2max = 70.597 - (0.185 \times Age) + (0.097 \times Height) - (0.246 \times Weight) - (0.122 \times HR)$.

Quality-of-life measurements

The Obesity and Weight-Loss Quality of Life Instrument (OWLQOL) and Weight-Related Symptom Measure (WRSM) are complementary instruments designed to evaluate obesity-related quality of life and symptoms (Niero et al., 2002). The OWLQOL consists of 33 items rated on a 7-point scale, ranging from 0 ("Not at all") to 6 ("A very great deal"). The OWLQOL comprises 4 domain subscales: self-image (SI), social stigma (SS), trying to lose weight (LW), and physical health (PH). Scores are derived by summing individual item responses and then converting this raw score to a standardized scale of 0–100. A score of 0 indicates the greatest impact, while 100 indicates the lowest impact—thus, increasing OWLQOL scores imply better QoL (Patrick et al., 2004). The WRSM, on the other hand, is a 20-item self-report measure that assesses the presence and bothersomeness of obesity-related symptoms. Participants indicate whether they have experienced each symptom in the past 4 weeks (yes/no) and rate its bothersomeness on a 7-point scale from 0 ("not at all") to 6 ("a very great deal"). The total score, calculated by summing the bothersomeness scores, ranges from 0 to 120, with higher scores indicating a greater symptom burden (Niero et al., 2002; Patrick et al., 2004).

The Physical Activity Enjoyment Scale (PACES) is a widely used instrument to assess the level of enjoyment individuals experience during physical activity. This scale is particularly useful in understanding motivation and adherence to exercise programs (Mullen et al., 2011). The PACES is particularly relevant in weight loss interventions as enjoyment of physical activity is strongly associated with adherence to exercise programs. PACES consists of 18 items, each rated on a 7-point bipolar scale, ranging from 0 to 90. Participants respond to statements about their feelings towards physical activity, such as "I enjoy it" versus "I hate it" or "It's very pleasant" versus "It's very unpleasant". Higher scores on the PACES indicate greater levels of enjoyment during physical activity (Mullen et al., 2011; Teques et al., 2020).

Intervention

The LI-RCT intervention consisted of a 12-week online exercise program delivered through Google Sheets, featuring detailed exercise instructions and descriptions. Sessions occurred 4-6 times per week, with each lasting 50-60 minutes. Each session incorporated dynamic warm-up and static cool-down stretches, with the main workout featuring two daily alternating routines that target different muscle groups throughout the week, allowing adequate recovery time. The workout consisted of 6-8 exercise groups, structured as multiple circuits where participants performed exercises continuously with 15-20 second rest intervals between exercises and circuits, followed by longer 60-90 second rest periods between groups.

The program utilized lightweight equipment including dumbbells (or alternative household items) and resistance bands, and participants had the flexibility to complete workouts either at home or in a gym setting. Program support began with an initial Zoom orientation call to explain the structure and proper exercise execution. Weekly follow-up video calls were conducted to monitor adherence and collect participant feedback to make necessary program modifications for the subsequent week.

Intensity monitoring and adjustment were crucial components of the program. Load intensity was individually determined using the modified Karvonen formula: Target Heart Rate = ((220-age) – RHR) × target intensity) + RHR (Ignaszewski et al., 2017). Participants controlled their pulse by checking their radial artery for 15 seconds post-exercise and multiplying the result by 4. While not the most precise method, this technique has been proven by Csepregi et al., 2022 to be reliable and cost-effective. The program's intensity was progressively adjusted each week through added weights, more challenging exercise modifications, or increased repetitions or sets.

Statistical analysis

The statistical analysis utilized RStudio. Descriptive statistics (means and standard errors with 95% confidence interval) were calculated for all variables and were recorded in Microsoft Excel. Data normality was assessed using the Shapiro-Wilk test. Baseline comparisons between LI-RCTG and CG groups employed independent t-tests for normally distributed data, Mann-Whitney U tests for non-parametric data, and chi-square tests for categorical data. Group differences over time were evaluated using two-way repeated measures ANOVA for normal data and aligned rank transform before ANOVA for non-parametric data. Post-hoc tests with Bonferroni correction were used following any significant result of the ANOVA tests, with paired t-tests for normal data and Wilcoxon Sign-rank tests for non-normal data. All statistical tests used a significant level of $\alpha = 0.05$.

Results

For baseline comparisons, the LI-RCTG participants were significantly older (29 ± 3.15) than the CG (24.45 ± 1.46, p = 0.021). The distribution of obesity and overweight was similar between groups, with 7 obese and 5 overweight participants in LI-RCTG, and 6 obese and 5 overweight participants in CG. Both groups showed comparable anthropometric and CV measurements. QoL assessments showed comparable OWLQOL and WRSM scores. However, PACES scores were significantly lower (p = 0.015) in LI-RCTG (47 ± 5.03) compared to CG (56.73 ± 3.3) – see: Table 1.

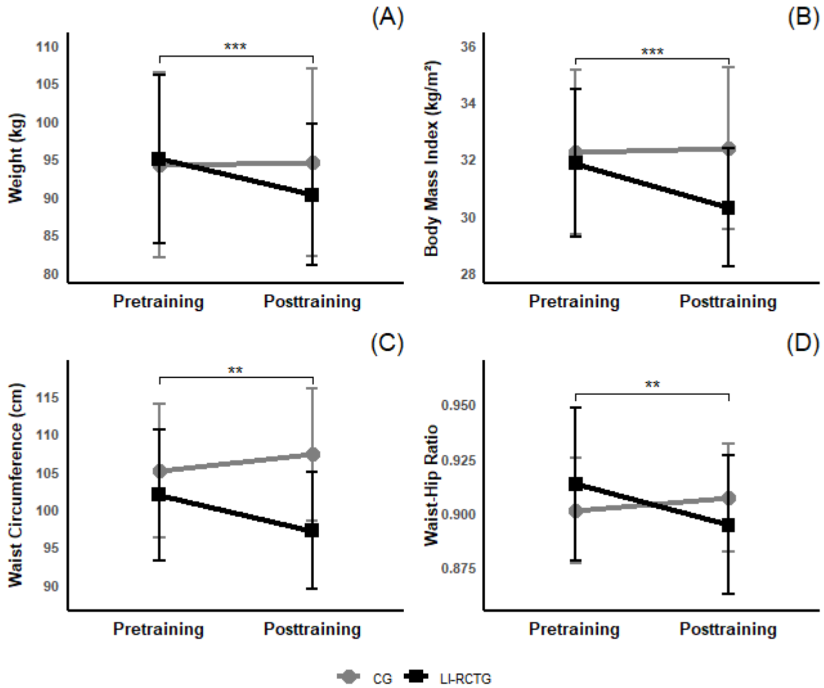
Table 1: Baseline characteristics of LI-RCTG and CG participants. Source: the Author

Variable	LI-RCTG (n = 12)	CG (n = 11)	p-value
Age *(years)*	29 ± 3.15	24.45 ± 1.46	0.021*
Obesity (Overweight)	7 (5)	6 (5)	1
Anthropometrics			
Hip circumference *(cm)*	111.62 ± 8.51	116.57 ± 8.8	0.442
Height *(m)*	1.72 ± 0.05	1.7 ± 0.05	0.610
Body weight *(kg)*	94.94 ± 11.07	94.08 ± 12.2	0.920
BMI *(kg/m^2)*	31.82 ± 2.6	32.22 ± 2.87	0.843
Waist circumference *(cm)*	101.84 ± 8.68	105.09 ± 8.86	0.525
Waist-hip ratio	0.91 ± 0.04	0.9 ± 0.02	0.582
Physical Fitness			
Resting heart rate *(bpm)*	96.25 ± 3.43	96.39 ± 3.9	0.957
Systolic blood pressure *(mmHg)*	111.63 ± 4.5	115.95 ± 2.21	0.405
Diastolic blood pressure *(mmHg)*	76.17 ± 2.56	79.05 ± 1.13	0.216
Estimated VO_2max *(ml/kg/min)*	24.57 ± 3.16	25.75 ± 3.43	0.625
Quality of Life			
OWLQOL	41.12 ± 4.39	43.21 ± 4.35	0.515
WRSM	40.25 ± 5.49	37.73 ± 5.02	0.513
PACES	47 ± 5.03	56.73 ± 3.3	0.015*

Note: Significant differences (p < 0.05) were marked with asterisks (*). Data are presented as mean ± 95% CI. OWLQOL – Obesity and Weight-loss Quality of Life, WRSM – Weight-Related Symptom Measure, PACES – Physical Activity Enjoyment Scale

The results in anthropometric outcomes of CG showed slight, non-significant increases in all parameters, while the LI-RCTG demonstrated significant decreases across all measurements from pre- to post-training. In the CG, weight increased marginally from 94.08 ± 12.2 to 94.52 ± 12.32 kg, while the LI-RCTG showed a significant reduction ($p < 0.001$) from 94.94 ± 11.07 to 90.21 ± 9.25 kg. Similarly, BMI in the CG increased slightly from 32.22 ± 2.87 to 32.35 ± 2.84 kg/m², whereas the LI-RCTG achieved a significant decrease ($p < 0.001$) from 31.82 ± 2.6 to 30.28 ± 2.08 kg/m². The CG's WC measurements increased from 105.09 ± 8.86 to 107.16 ± 8.77 cm, while the LI-RCTG showed a significant reduction ($p = 0.002$) from 101.84 ± 8.68 to 97.08 ± 7.74 cm. WHR measurements of the CG showed a slight increase, whereas LI-RCTG demonstrated a significant decrease ($p = 0.002$) from 0.91 ± 0.04 to 0.89 ± 0.03 (Figure 2).

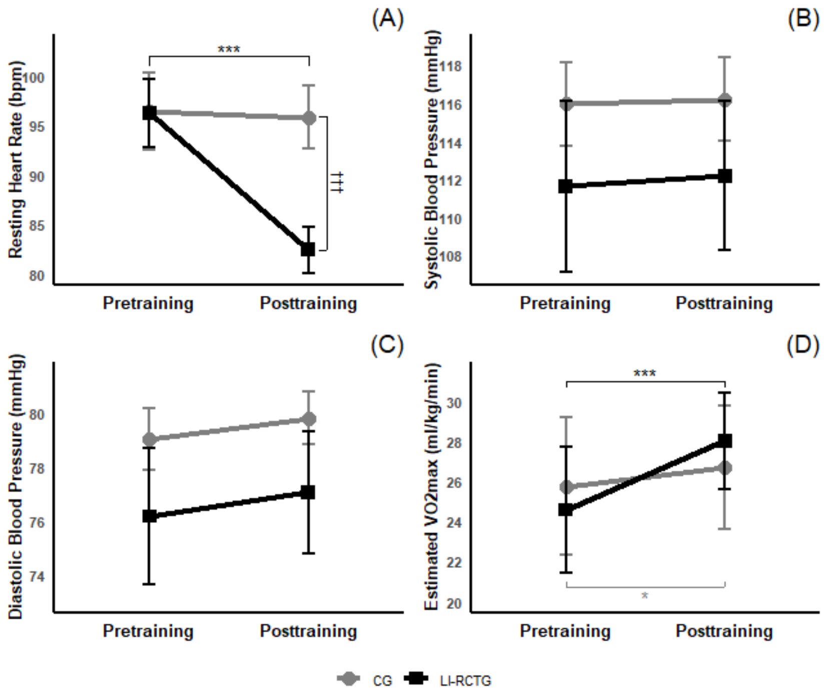
Figure 2: Changes in weight (A), BMI (B), waist circumference (C), and waist-to-hip ratio (D) between pre- and post-training measurements in LI-RCTG and CG. Source: the Author



Note: * indicate significant differences within group over time.
**** indicates p < 0.01 and**
***** indicates p < 0.001.**

While the CG showed minimal changes across physical fitness parameters, the LI-RCTG demonstrated notable improvements in RHR and estimated VO2max during the intervention period. The LI-RCTG's RHR decreased significantly ($p < 0.001$) from 96.25 ± 3.43 to 82.42 ± 2.33 bpm, while the CG remained nearly unchanged, shifting from 96.39 ± 3.9 to 95.82 ± 3.21 bpm. Additionally, RHR result of LI-RCTG was significantly lower than CG post-intervention. For estimated VO_2max, the LI-RCTG showed a significant improvement ($p < 0.001$) from 24.57 ± 3.16 to 28.01 ± 2.44 ml/kg/min, whereas the CG showed a more modest significant enhancement ($p = 0.015$) from 25.75 ± 3.43 to 26.71 ± 3.09 ml/kg/min. SBP and DBP measures remained relatively stable in both groups during the intervention period ($p = 0.649$ and $p = 0.895$ respectively – see: Figure 3).

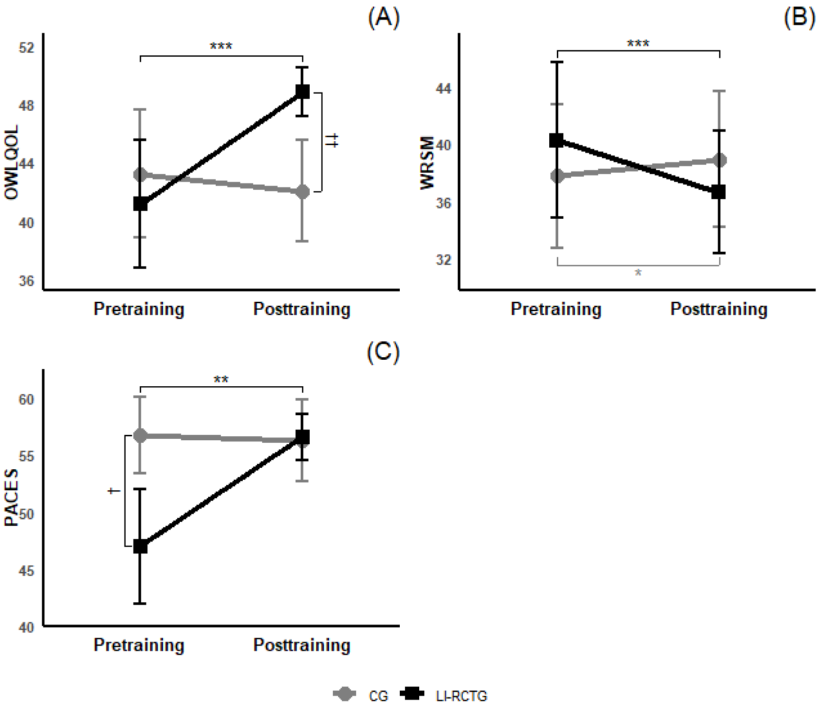
Figure 3: Changes in resting heart rate (A), systolic blood pressure (B), diastolic blood pressure (C), and estimated VO_2max (D) between pre- and post-training measurements in LI-RCTG and CG. Source: the Author



Note: * indicate significant differences within group over time,
† indicate significant differences between groups at the same time.
*** indicates p < 0.05, *** and ††† indicate p < 0.001.**

While the CG maintained relatively stable QoL scores, the LI-RCTG showed marked improvements across all QoL measures during the intervention period. In OWLQOL, the LI-RCTG showed substantial improvement ($p < 0.001$) from 41.12 ± 4.39 to 48.79 ± 1.65, while the CG slightly decreased from 43.21 ± 4.35 to 42.04 ± 3.5. Post-intervention OWLQOL scores were significantly higher in the LI-RCTG compared to the CG ($p < 0.01$). The LI-RCTG experienced a significant reduction ($p < 0.001$) in WRSM scores, with scores decreasing from 40.25 ± 5.49 to 36.58 ± 4.28. Conversely, the CG showed a significant increase ($p = 0.046$) in bothersomeness from 37.73 ± 5.02 to 38.91 ± 4.72. The LI-RCTG demonstrated substantial improvement in PACES ($p = 0.002$), increasing from 47 ± 5.03 to 56.58 ± 2.01, while the CG maintained relatively stable scores (56.73 ± 3.3 to 56.27 ± 3.58) (Figure 4).

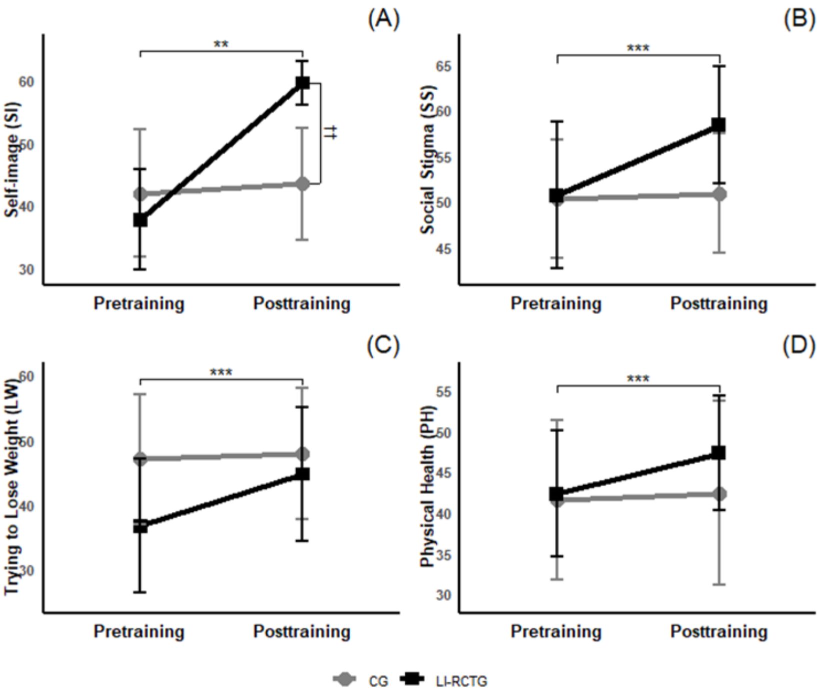
Figure 4: Changes in (A) Obesity and Weight-Related Quality of Life (OWLQOL), (B) Weight-Related Symptom Measure (WRSM), and (C) Physical Activity Enjoyment Scale (PACES) scores between pre- and post-training in LI-RCTG and CG. Source: the Author



Note: * indicate significant differences within group over time
† indicate significant differences between groups at the same time
**** and † indicates p < 0.05 ** and †† indicate p < 0.01 *** indicate p < 0.001**

In the subdomains of OWLQOL, SI scores in the LI-RCTG showed significant improvement ($p = 0.002$), increasing from 37.71 ± 7.93 to 59.46 ± 3.39, while the CG showed minimal change. Similarly, LW scores in the LI-RCTG improved significantly ($p < 0.001$) from 36.67 ± 10.3 to 44.67 ± 10.3, compared to the CG's modest increase. SS scores demonstrated significant improvement ($p < 0.001$) in the LI-RCTG, increasing from 50.65 ± 8.02 to 58.32 ± 6.41, while the CG maintained stable scores. PH also showed remarkable enhancement ($p < 0.001$) in the LI-RCTG, improving from 42.22 ± 7.73 to 47.22 ± 7.04, compared to minimal changes in the CG (41.52 ± 9.74 to 42.33 ± 11.23 – see: Figure 5).

Figure 5: Changes in OWLQOL sub-domain scores before and after training between LI-RCTG and CG: (A) self-image, (B) social stigma, (C) trying to lose weight, and (D) physical health. Source: the Author



Note: * indicate significant differences within group over time
† indicate significant differences between groups at the same time
** and †† indicate $p < 0.01$ *** indicate $p < 0.001$

When comparing the effectiveness of LI-RCT in overweight and obese participants, in terms of anthropometric measurements, both groups showed improvements, with the obesity group demonstrating more significant changes. Weight reduction was particularly notable in the obesity group (106 ± 14.1 to 99 ± 11.7 kg, $p = 0.022$). BMI and WC also decreased significantly in the obese group (BMI: 34.8 ± 2.54 to 32.7 ± 1.96 kg/m², WC: 108 ± 12.8 to 102 ± 12 cm, $p < 0.05$). Regarding physical fitness parameters, RHR decreased substantially in both groups, with the obesity group demonstrating a significant reduction ($p = 0.016$) from 97.7 ± 4.34 to 80.8 ± 2.9 bpm. BP measures remained relatively stable, showing only minor changes in both groups. Additionally, estimated VO_2max improved in both groups, with the obese group achieving a significant increase ($p = 0.016$) from 21.1 ± 3.44 to 25.7 ± 2.78 ml/kg/min. QoL parameters improved in all aspects for both groups. WRSM scores decreased significantly in the obesity group (45.1 ± 6.84 to 40.4 ± 5.32, $p = 0.021$). PACES scores increased markedly in both groups, with the obesity group showing significant improvement ($p = 0.022$) from 50 ± 5.83 to 57.1 ± 2.95 (Table 2).

Discussion

Our comprehensive analysis yielded several significant findings that aligned with our initial hypothesis. The LI-RCTG demonstrated notable improvements compared to the CG in anthropometric measurements, with WC showing the strongest intervention effect among weight, BMI, WC, and WHR measures. In terms of physical fitness, participants showed significant improvements in RHR and estimated VO_2max, though BP remained relatively stable across both groups. QoL metrics also improved substantially, with particularly strong results in OWLQOL and PACES scores, the latter showing the highest intervention effect, while participants also reported meaningful reductions in weight-related symptoms as measured by WRSM scores.

The anthropometric data analysis revealed significant improvements in the LI-RCTG compared to CG, showing notable reductions in weight, BMI, WC, and WHR. These findings align with several key studies in the literature, including Kim et al., 2018 who reported similar improvements in obese female college students over 12 weeks of resistance circuit training (RCT) and Beqa Ahmeti et al., 2020 who found comparable reductions in young healthy adult women over 8 weeks of RCT. A systematic review by Seo et al., 2019 reported significant effects of RCT on body weight and BMI, particularly in overweight and obese participants. They found that statistically significant weight loss by RCT occurred primarily in women with attendance rates above 90% – supporting our results given our 92.7% adherence rate.

Table 2: Changes in measurements of overweight and obese individuals after LI-RCT. Source: the Author

Variable	Groups	Difference over time			G × T	
		Pre	Post	p-value	F-value	p-value
Anthropometrics						
Weight *(kg)*	Overweight	80.2 ± 5.88	78 ± 5.48	0.058	43.92	5.87×10^{-5} ###
	Obesity	106 ± 14.1	99 ± 11.7	0.022 *		
BMI *(kg/m²)*	Overweight	27.7 ± 1.74	26.9 ± 1.46	0.062	10.24	0.009 ##
	Obesity	34.8 ± 2.54	32.7 ± 1.96	0.016 *		
WC *(cm)*	Overweight	93 ± 5.11	90.6 ± 4.53	0.062	19.52	0.001 ##
	Obesity	108 ± 12.8	102 ± 12	0.021 *		
WHR	Overweight	0.91 ± 0.06	0.9 ± 0.06	_	3.11	0.108
	Obesity	0.92 ± 0.05	0.89 ± 0.04	_		
Physical Fitness						
RHR *(bpm)*	Overweight	94.2 ± 5.58	84.7 ± 3.05	0.062	15.19	0.003 ##
	Obesity	97.7 ± 4.34	80.8 ± 2.9	0.016 *		
SBP *(mmHg)*	Overweight	107 ± 5.67	108 ± 5	0.098	9.88	0.01 #
	Obesity	115 ± 5.33	115 ± 5.12	0.181		
DBP *(mmHg)*	Overweight	76 ± 3.44	78 ± 3.07	0.136	5.01	0.049 #
	Obesity	76.3 ± 3.86	76.6 ± 3.36	0.586		
VO_2max *(ml/kg/min)*	Overweight	29.4 ± 1.74	31.3 ± 2.32	0.062	23.32	6.92×10^{-4} ###
	Obesity	21.1 ± 3.44	25.7 ± 2.78	0.016 *		
Quality of Life						
OWLQOL	Overweight	35.5 ± 3.83	47.9 ± 1.32	0.054	13.37	0.004 ##
	Obesity	45.1 ± 5.38	49.4 ± 2.67	0.074		
WRSM	Overweight	33.4 ± 4.86	31.2 ± 3.69	0.054	7.97	0.018 #
	Obesity	45.1 ± 6.84	40.4 ± 5.32	0.021 *		
PACES	Overweight	42.8 ± 8.16	55.8 ± 2.73	0.058	8.21	0.017 #
	Obesity	50 ± 5.83	57.1 ± 2.95	0.022 *		

Note: Data are presented as mean ± 95% CI. (*) indicates significant differences within group over time, (# indicates significant interaction effects between group and time. (*) indicates p < 0.05, (##) indicates p < 0.0 (###) indicates p < 0.001. G × T: group × time interaction effects. BMI – Body Mass Index, WC – Wai Circumference, WHR – Waist-Hip Ratio. RHR – Resting Heart Rate, SBP – Systolic Blood Pressure, DBP Diastolic Blood Pressure. OWLQOL – Obesity and Weight-loss Quality of Life, WRSM – Weight-Relate Symptom Measure, PACES – Physical Activity Enjoyment Scale.

The most recent meta-analysis by Hu et al., 2024 further corroborated these findings, demonstrating reductions in BMI, WHR, and body weight after a RCT intervention. However, several studies reported contrasting results showing no significant changes in body composition—Taipale et al., 2013, Sperlich et al., 2018, and Jackson et al., 2018. These differences can be explained by variations in study design: Taipale et al., 2013 focused on male endurance runners, Sperlich et al., 2018 employed brief interventions of only 6 minutes daily over 4 weeks, and Jackson et al., 2018 worked with sedentary females while concealing the study's weight loss objectives. As King et al., 2008 noted, weight loss outcomes often depend more on participants' intentions to lose weight and their eating habits than on exercise alone, which explains the lack of significant changes in body composition reported by Jackson et al., 2018. Since our study, like many others, did not strictly control participants' diets, the observed reductions in weight and BMI may reflect broader lifestyle changes driven by weight loss intentions.

Analysis of physical fitness metrics revealed significant improvements in RHR and estimated VO_2max in the LI-RCTG compared to CG, while blood pressure remained stable. These findings are consistent with several meta-analyses and studies. For example, Seo et al., 2019 and Kaikkonen et al., 2000 observed comparable VO_2max improvements to our findings. A systematic review by Ramos-Campo et al., 2021 further validated these results, showing that circuit training improved VO_2max by an average of 6.3%. Additionally, Hu et al., 2024 demonstrated enhanced cardiorespiratory endurance through improved 6-minute walk test (6MWT). These improvements in VO_2max can be attributed to optimal training session duration, systemic heart rate monitoring, and carefully calculated work-rest ratios that provide adequate aerobic stimulus (Kaikkonen et al., 2000). Regarding blood pressure, Abdelaal & Mohamad, 2015 found AE training more effective than RCT for blood pressure reduction, which aligns with our study's finding of no significant changes in BP after RCT. However, not all studies reported positive outcomes. Taipale et al., 2013 found no significant VO_2max changes in male endurance runners, likely due to their higher baseline fitness levels ($VO_2max = 51.3 \pm 5.2$), which leave less room for improvement. Similarly, Sperlich et al., 2018 reported no cardiorespiratory improvements, possibly due to their brief intervention period (6 minutes daily x 4 weeks).

Quality of life assessments revealed significant improvements, with the LI-RCTG showing substantial enhancements in both OWLQOL and PACES scores and significant reductions in WRSM scores. These findings align with previous research on RCT, particularly Ambak et al., 2018's study of obese and overweight housewives, which reported similar improvements in OWLQOL scores with notable gains in self-image and physical health domains. While Berge et al., 2022 study of severely obese adults showed only insignificant decreases in WRSM scores after RCT, our intervention achieved significant reductions—likely because we included only overweight and obese participants, excluding those with severe obesity. Our findings support Cash et al., 2012's research showing that BMI reduction and increased physical activity improve obesity-specific health-related quality of life, particularly in women, as evidenced by our participants' substantial improvements in both OWLQOL and PACES scores alongside significant BMI reduction.

From a cardiovascular health perspective, our findings demonstrate significant implications from improvements in weight loss, WC, WHR, RHR, and VO_2max. These changes enhance overall cardiovascular function through multiple interconnected mechanisms. The reduction in abdominal fat (shown by reduced WC and WHR) and enhanced cardiorespiratory fitness decrease inflammatory mediators from fat tissue, reducing systemic inflammation that contributes to atherosclerosis (Jia & Liu, 2021).

Chandran, 2021 supports this finding, showing a significant correlation between WHR and VO_2max, indicating that lower abdominal fat levels correlate with higher cardiorespiratory fitness and decreased CV risk. Després, 2014 further demonstrated that WC effectively discriminates CV and metabolic risk, with WC improvements associated with better lipid profiles. These reductions in WC and WHR can improve insulin sensitivity and create favorable changes in lipid profiles, including reduced total cholesterol and LDL while increasing HDL levels, which helps prevent plaque formation in blood vessels (Guha et al., 2021). Our study also revealed improved blood vessel function through enhanced nitric oxide availability from weight loss and better endothelial function associated with increased VO_2max (H. W. Kim et al., 2020). These vascular improvements, combined with lower RHR, indicate enhanced cardiovascular efficiency (Pooja, 2017). Together, these benefits – reduced inflammation, improved insulin sensitivity, better lipid profiles, and enhanced vascular function – decrease the risk of heart failure and arrhythmias while supporting long-term CV health through reduced cardiac strain. However, it is important to note that since our study did not include lipid profile or hormonal measurements, the aforementioned cardiovascular benefits remain theoretical possibilities rather than confirmed outcomes. Future studies should address this limitation by incorporating comprehensive blood tests alongside the anthropometric and fitness measurements used in our study to validate these potential cardiovascular improvements.

Beyond physical health improvements, our findings suggest significant psychological and social implications for individuals with obesity. The notable reductions in WC, BMI, and WHR, combined with enhanced OWLQOL and PACES scores, indicate that LI-RCT can help address body image concerns and improve self-esteem. As research by Weinberger & Luck-Sikorski, 2021 shows, these physical improvements often correlate with better psychological outcomes, potentially helping to break the cycle of negative self-perception that many individuals with obesity experience. The program's success in improving physical fitness parameters (RHR and VO_2max) while reducing weight-related symptoms (WRSM scores) suggests it could help combat weight stigma by empowering participants with tangible health improvements. This may lead to increased confidence in various social settings, from healthcare interactions to educational and workplace environments, where individuals with obesity often face discrimination (De Wit et al., 2022). Furthermore, the high adherence rates and positive PACES scores in our study suggest that LI-RCT could provide a supportive environment for physical activity, potentially counteracting the social isolation and exclusion often reported by individuals with obesity. The comprehensive improvements in both physical and quality-of-life measures indicate that LI-RCT could serve as an effective intervention to address not only the physical aspects of obesity but also its associated psychological and social challenges. However, future correlation studies should be conducted to confirm whether there is a direct relationship between QoL instrument scores and decreased bodyweight, WC, and WHR, as our study's conclusions were based solely on mean differences pre and post training. Regarding practical applications, our findings suggest promising potential for implementing LI-RCT in university settings. Our hybrid approach, combining online-based delivery with weekly face-to-face counseling, achieved a remarkable 92.7% adherence rate and demonstrated positive results across both overweight/obese and lean individuals, though some results were insignificant. This aligns with evidence from the ACC/AHA Task Force on Practice Guidelines, 2014, which showed that electronically delivered comprehensive weight loss programs in academic settings can achieve significant results, including weight losses of up to 5 kg over 6-12 months. The program's adaptability and lower impact nature particularly benefit those with lower fitness levels or time constraints, making it well-suited for academic environments. Furthermore, the program's flexibility in accommodating individual preferences and circumstances could enhance adherence among female students who might otherwise be hesitant to participate in traditional exercise programs. These findings suggest that LI-RCT could be effectively integrated into university wellness programs as a sustainable and accessible approach to improving student health outcomes.

Future research should focus on several key areas to strengthen our findings. Expanding the study of LI-RCT across diverse populations and settings would improve the generalizability of our results. More rigorous evidence could be established through controlled dietary interventions and standardized measurement protocols, helping isolate the intervention's specific effects and facilitate better cross-study comparisons. Adding comprehensive outcome measures – including blood tests for lipid profiles and hormones – would offer deeper insights into physiological changes. Correlation studies are needed to verify the direct relationship between quality-of-life scores and improvements in bodyweight, waist circumference, and waist-to-hip ratio, since our current conclusions rely only on pre- and post-training mean differences. Lastly, research should determine the optimal dosage, frequency, and intensity of LI-RCT for maximum effectiveness.

Conclusion

In conclusion, this study provides compelling evidence for the effectiveness of LI-RCT in improving both physical and psychological health outcomes among overweight and obese female university students. The intervention demonstrated significant improvements in anthropometric measures, cardiorespiratory fitness, and quality of life indicators, with particularly pronounced benefits observed in obese participants. The high adherence rate and positive participant engagement suggest that LI-RCT represents a feasible and sustainable approach to exercise intervention in academic settings. While acknowledging certain methodological limitations, particularly regarding sample size and measurement standardization, this research contributes valuable insights to the growing body of evidence supporting alternative exercise modalities for weight management and health promotion. The findings underscore the potential of hybrid delivery models combining online and face-to-face components, which could prove particularly relevant in today's increasingly digital educational landscape. Moving forward, the implementation of such programs in university settings could play a crucial role in addressing the complex challenges of obesity management while promoting overall student well-being.

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