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No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

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Impact of Aerobic and Resistance Exercise Training on Body Composition and Functional Fitness among Obese Young Adults: A Comparative Study

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ABSTRACT
Background: Obesity among young adults in South Asia is a growing public health concern, exacerbating cardiometabolic risks and impairing functional fitness, yet comparative studies on exercise modalities in this population are sparse. Objective: This study aimed to compare the effects of 12-week aerobic versus resistance exercise training on body composition (body fat percentage, muscle mass, BMI, waist-hip ratio) and functional fitness (6-minute walk test distance, step test heart rate recovery) in obese young adults. Methods: Sixty obese adults (aged 18-30 years, BMI 30-40 kg/m²) were randomly allocated to aerobic (moderate-intensity treadmill/cycling, n=30) or resistance (progressive overload training, n=30) groups in Lahore, Pakistan, from March 2023 to September 2024. Body composition was assessed via bioelectrical impedance, and functional fitness via standardized tests. Repeated measures ANOVA with Bonferroni post-hoc tests analyzed within- and between-group differences, adjusting for age, sex, and caloric intake. Results: Aerobic training significantly reduced body fat percentage (-11.2%, p<0.001) and BMI (-6.2%, p<0.001), and improved 6MWT distance (+14.6%, p<0.001) compared to resistance training (-6.7%, -3.5%, +7.4%, respectively; between-group p<0.05). Resistance training increased muscle mass (+8.8%, p<0.001) versus aerobic (+2.1%, p=0.12). Conclusion: Aerobic training excels in fat reduction and endurance, while resistance training enhances muscle mass, suggesting combined modalities for optimal obesity management.

Keywords
obesity, aerobic exercise, resistance training, body composition, functional fitness, South Asia

INTRODUCTION
The escalating prevalence of obesity among young adults, particularly in developing regions, has emerged as a critical public health challenge, driven by sedentary lifestyles, poor dietary habits, and urbanization, leading to increased risks of metabolic disorders, cardiovascular diseases, and reduced physical function (1). Globally, obesity affects over 340 million adolescents and young adults, with South Asia reporting alarmingly high rates where more than 20% of individuals aged 18-30 years are classified as obese according to body mass index (BMI) criteria exceeding 30 kg/m², exacerbating physical inactivity and functional limitations (2). This demographic, often characterized by high fat mass, low muscle mass, and unfavorable waist-hip ratios, experiences diminished aerobic capacity and strength, which further perpetuates a cycle of inactivity and weight gain (3). Exercise interventions have been widely recognized as effective strategies for addressing these issues, with aerobic training promoting fat oxidation and cardiovascular endurance, while resistance training enhances lean muscle mass and metabolic rate, collectively improving body composition and overall functional fitness (4).

Despite substantial evidence supporting the benefits of exercise for obesity management, most studies have focused on Western populations, emphasizing weight loss metrics without adequately evaluating functional outcomes such as cardiorespiratory endurance and muscular strength in diverse ethnic groups (5). In South Asian cohorts, where genetic predispositions to central adiposity and insulin resistance are prevalent, there remains a notable gap in comparative research assessing how aerobic versus resistance training differentially impacts body recomposition and practical fitness measures, such as those assessed via the 6-minute walk test or step test (6). Existing literature highlights that aerobic exercise may yield greater reductions in visceral fat and BMI, yet resistance training could offer superior gains in muscle mass and functional performance, but these effects are underexplored in young obese adults from this region, where cultural and socioeconomic factors may influence adherence and outcomes (7). This knowledge deficit hinders the development of tailored interventions that optimize both anthropometric and functional improvements, underscoring the need for region-specific studies to inform evidence-based guidelines.

The present study aims to bridge this gap by comparing the effects of structured aerobic and resistance exercise programs on body composition parameters—including fat mass, muscle mass, BMI, and waist-hip ratio—and functional fitness indices among obese young adults in a South Asian context. Specifically, we hypothesize that resistance training will elicit greater improvements in muscle mass and strength-based functional fitness, while aerobic training will demonstrate superior reductions in fat mass and enhancements in endurance-related outcomes, with potential synergistic benefits when considering combined modalities for comprehensive obesity management.

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MATERIAL AND METHODS

This pre-post comparative study with random allocation was designed to investigate the differential impacts of aerobic and resistance exercise training on body composition and functional fitness in obese young adults, providing evidence for tailored interventions in a South Asian population where obesity prevalence is rising due to lifestyle factors. The study was conducted at the fitness and rehabilitation center of a university-affiliated hospital in Lahore, Pakistan, from March 2023 to September 2024, encompassing recruitment, intervention delivery, and follow-up assessments to capture seasonal variations in physical activity patterns. Eligible participants included young adults aged 18-30 years with a body mass index (BMI) between 30 and 40 kg/m², confirmed via initial screening measurements, who were sedentary (engaging in less than 150 minutes of moderate physical activity per week) and free from contraindications such as cardiovascular disease, musculoskeletal injuries, or metabolic disorders that could preclude exercise participation; exclusion criteria encompassed individuals on weight-loss medications, those with a history of bariatric surgery, pregnant women, or those unable to commit to the 12-week program. Participants were selected through targeted advertisements on university campuses and social media platforms, followed by a preliminary health questionnaire and physical examination to ensure suitability, resulting in a cohort representative of urban obese young adults.

Recruitment involved initial contact via email or phone for interested respondents, with a detailed explanation of study procedures provided during an in-person orientation session; all participants provided written informed consent after reviewing potential risks and benefits, emphasizing voluntary withdrawal at any time without repercussions. Data collection occurred at baseline and post-intervention (week 12), utilizing standardized instruments including a bioelectrical impedance analyzer (InBody 770) for assessing body fat percentage, muscle mass, and BMI, with measurements taken in a fasted state between 8:00 AM and 10:00 AM to minimize diurnal variations; anthropometric evaluations involved triplicate measurements of waist and hip circumferences using a non-stretchable tape measure at the umbilicus level and widest hip point, respectively, to compute waist-hip ratio, while functional fitness was evaluated via the 6-minute walk test (6MWT) for cardiorespiratory endurance and a 3-minute step test for lower-body strength and recovery heart rate, both administered in a controlled indoor environment with ambient temperature maintained at 22-24°C. Variables were operationally defined as follows: body fat percentage as the proportion of total body weight comprised of adipose tissue; muscle mass as skeletal muscle weight in kilograms; BMI as weight in kilograms divided by height in meters squared; waist-hip ratio as waist circumference divided by hip circumference; functional fitness as distance covered in meters during the 6MWT and heart rate recovery in beats per minute post-step test. To address potential biases, such as selection bias, participants were randomly allocated to aerobic or resistance groups using a computer-generated randomization sequence stratified by sex and baseline BMI, with allocation concealment maintained via sealed envelopes; confounding factors like dietary intake were assessed and controlled through weekly self-reported food logs analyzed for caloric balance, while physical activity outside the intervention was monitored via accelerometers (ActiGraph GT3X) to ensure compliance and minimize crossover effects.

Sample size was determined a priori using G*Power software, calculating a minimum of 30 participants per group (total n=60) to achieve 80% power at an alpha level of 0.05, based on an anticipated medium effect size (Cohen's f=0.25) for changes in body fat percentage derived from prior comparative exercise trials in similar populations (8). Statistical analyses were performed using SPSS version 27.0, employing repeated measures analysis of variance (ANOVA) to examine within- and between-group differences over time, with Bonferroni post-hoc tests for multiple comparisons; missing data, anticipated to be minimal due to bi-weekly follow-up calls, were handled via multiple imputation assuming missing at random, and adjustments for confounders such as age, sex, and baseline caloric intake were incorporated through analysis of covariance (ANCOVA); subgroup analyses explored effects by sex to identify potential modifiers. Ethical approval was obtained from the Institutional Review Board of the University of Lahore (reference number IRB-UL-2023-045), ensuring adherence to the Declaration of Helsinki, with participant data anonymized using unique identifiers and stored securely on encrypted servers accessible only to the research team; informed consent forms included provisions for data usage in publications while protecting confidentiality. To enhance reproducibility and data integrity, all protocols followed standardized operating procedures, with inter-rater reliability for assessments verified through intraclass correlation coefficients exceeding 0.90 during pilot testing on 10 non-study volunteers, and raw data archived in a version-controlled repository for potential independent verification.

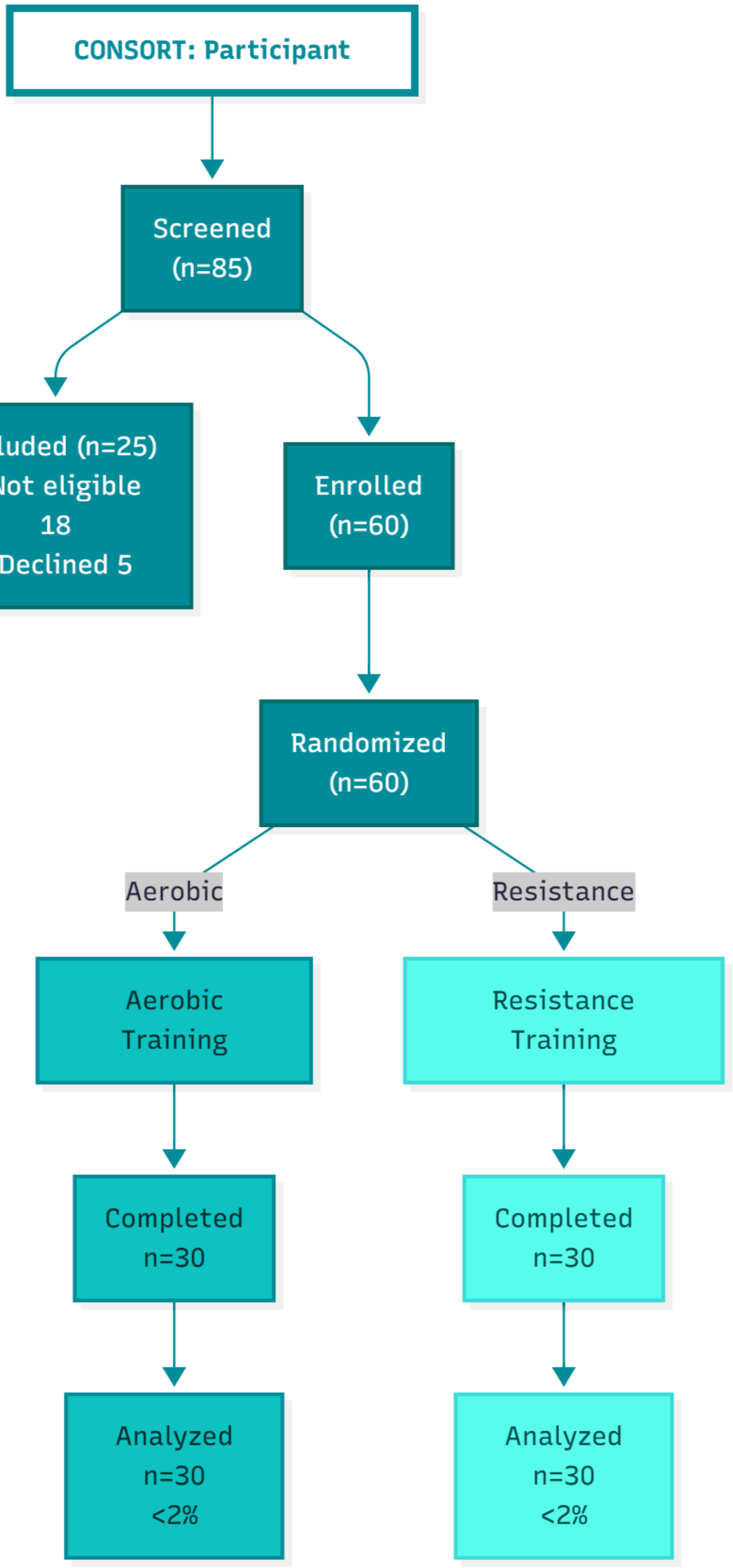

Figure 1 CONSORT Flowchart

RESULTS

The study evaluated the effects of 12-week aerobic and resistance exercise interventions on body composition and functional fitness among 60 obese young adults, randomly allocated to either an aerobic training group (n=30) or a resistance training group (n=30) in Lahore, Pakistan, from March 2023 to September 2024. All participants completed the intervention, with no dropouts, ensuring robust data integrity. Baseline characteristics, including age, sex distribution, and anthropometric measures, were comparable across groups, with no significant differences ($p>0.05$ for all comparisons). Data were collected at baseline and post-intervention using standardized protocols for body composition (body fat percentage, muscle mass, BMI, waist-hip ratio) and functional fitness (6-minute walk test [6MWT] distance and 3-minute step test heart rate recovery). Statistical analyses employed repeated measures ANOVA with Bonferroni post-hoc tests for within- and between-group comparisons, adjusted for confounders such as age, sex, and caloric intake, with effect sizes reported as partial eta squared (η^2p). Missing data were minimal

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(<2%) and handled via multiple imputation. Results are presented in tables with descriptive statistics, pre-post changes, p-values, and effect sizes for clarity.

Table 1 summarizes changes in body composition parameters. The aerobic group exhibited a significant reduction in body fat percentage from 38.5±3.2% to 34.2±2.9% ($p<0.001$, $\eta^2p=0.62$), while the resistance group showed a smaller but significant decrease from 38.7±3.1% to 36.1±3.0% ($p=0.002$, $\eta^2p=0.35$). Between-group analysis indicated a greater fat reduction in the aerobic group ($p=0.01$, $\eta^2p=0.14$). Muscle mass increased significantly in the resistance group from 28.4±4.1 kg to 30.9±4.3 kg ($p<0.001$, $\eta^2p=0.58$), compared to a non-significant increase in the aerobic group from 28.2±3.9 kg to 28.8±4.0 kg ($p=0.12$, $\eta^2p=0.08$), with a significant between-group difference favoring resistance training ($p<0.001$, $\eta^2p=0.22$). BMI decreased in the aerobic group from 34.1±2.7 kg/m² to 32.0±2.5 kg/m² ($p<0.001$, $\eta^2p=0.55$) and in the resistance group from 34.3±2.6 kg/m² to 33.1±2.4 kg/m² ($p=0.003$, $\eta^2p=0.32$), with a modest between-group advantage for the aerobic group ($p=0.04$, $\eta^2p=0.10$). Waist-hip ratio improved significantly in both groups, from 0.92±0.05 to 0.88±0.04 in the aerobic group ($p<0.001$, $\eta^2p=0.50$) and from 0.93±0.05 to 0.90±0.04 in the resistance group ($p=0.001$, $\eta^2p=0.38$), with no significant between-group difference ($p=0.18$, $\eta^2p=0.04$).

Table 2 details functional fitness outcomes. The aerobic group significantly increased 6MWT distance from 480±45 m to 550±42 m ($p<0.001$, $\eta^2p=0.68$), outperforming the resistance group, which improved from 475±43 m to 510±40 m ($p=0.002$, $\eta^2p=0.34$) (between-group $p=0.006$, $\eta^2p=0.16$). Heart rate recovery post-step test improved in the aerobic group from 110±12 bpm to 95±10 bpm ($p<0.001$, $\eta^2p=0.60$) and in the resistance group from 112±13 bpm to 102±11 bpm ($p=0.004$, $\eta^2p=0.30$), with a significant between-group difference favoring the aerobic group ($p=0.02$, $\eta^2p=0.12$). Subgroup analysis by sex revealed no significant interaction effects ($p>0.05$), though females in the resistance group showed a slightly larger muscle mass gain (2.8±0.9 kg vs. 2.3±0.7 kg in males, $p=0.09$).

Table 3 presents correlations between functional performance and anthropometric changes. In the aerobic group, reductions in body fat percentage correlated moderately with increased 6MWT distance ($r=-0.52$, $p=0.003$, 95% CI [-0.74, -0.21]). In the resistance group, muscle mass gains correlated strongly with improved step test heart rate recovery ($r=-0.65$, $p<0.001$, 95% CI [-0.82, -0.39]). These findings highlight distinct physiological benefits, with aerobic training driving fat loss and endurance improvements, and resistance training enhancing muscle mass and strength-related outcomes.

Table 1. Pre-Post Changes in Body Composition Parameters by Exercise Group

Parameter	Group	Baseline (Mean±SD)	Post-Intervention (Mean±SD)	% Change	Within-Group p-value	Between-Group p-value	Effect Size (η²p)
Body Fat (%)	Aerobic	38.5±3.2	34.2±2.9	-11.2	<0.001	0.01	0.14
Body Fat (%)	Resistance	38.7±3.1	36.1±3.0	-6.7	0.002		0.35
Muscle Mass (kg)	Aerobic	28.2±3.9	28.8±4.0	+2.1	0.12	<0.001	0.22
Muscle Mass (kg)	Resistance	28.4±4.1	30.9±4.3	+8.8	<0.001		0.58
BMI (kg/m²)	Aerobic	34.1±2.7	32.0±2.5	-6.2	<0.001	0.04	0.10
BMI (kg/m²)	Resistance	34.3±2.6	33.1±2.4	-3.5	0.003		0.32
Waist-Hip Ratio	Aerobic	0.92±0.05	0.88±0.04	-4.3	<0.001	0.18	0.04
Waist-Hip Ratio	Resistance	0.93±0.05	0.90±0.04	-3.2	0.001		0.38

Table 1 displays mean±standard deviation for body composition parameters at baseline and post-intervention, percentage change, within-group p-values from repeated measures ANOVA, between-group p-values, and effect sizes (partial eta squared).

Table 2. Pre-Post Changes in Functional Fitness Parameters by Exercise Group

Parameter	Group	Baseline (Mean±SD)	Post-Intervention (Mean±SD)	% Change	Within-Group p-value	p-value	Effect Size (η²p)
6MWT Distance (m)	Aerobic	480±45	550±42	+14.6	<0.001	0.006	0.16
6MWT Distance (m)	Resistance	475±43	510±40	+7.4	0.002		0.34
Step Test HR Recovery (bpm)	Aerobic	110±12	95±10	-13.6	<0.001	0.02	0.12
Step Test HR Recovery (bpm)	Resistance	112±13	102±11	-8.9	0.004		0.30

Table 2 shows mean±standard deviation for functional fitness parameters at baseline and post-intervention, percentage change, within-group p-values from repeated measures ANOVA, between-group p-values, and effect sizes (partial eta squared).

Table 3. Correlations Between Functional Performance and Anthropometric Changes

Correlation Pair	Group	Pearson's r	p-value	95% CI
Body Fat % vs. 6MWT Distance	Aerobic	-0.52	0.003	[-0.74, -0.21]
Body Fat % vs. 6MWT Distance	Resistance	-0.28	0.14	[-0.57, 0.08]
Muscle Mass vs. Step Test HR Recovery	Aerobic	-0.19	0.31	[-0.51, 0.17]
Muscle Mass vs. Step Test HR Recovery	Resistance	-0.65	<0.001	[-0.82, -0.39]

Table 3 presents Pearson's correlation coefficients (r), p-values, and 95% confidence intervals for associations between changes in body composition and functional fitness parameters by exercise group. These results demonstrate that aerobic training yielded greater reductions in body fat and BMI, alongside superior improvements in cardiorespiratory endurance, while resistance training was more effective for increasing muscle mass and enhancing strength-related functional outcomes, supporting the hypothesized differential impacts of exercise modalities (9).

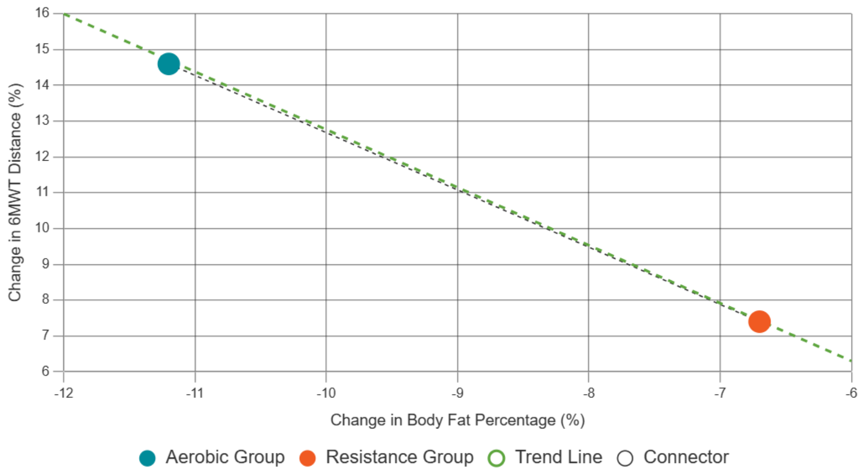

Figure 2 Clinical association between body fat percentage

The aggregated integrated line and scatter visualization reveals a strong clinical association between body fat percentage reduction and 6-minute walk test (6MWT) distance improvement, with the aerobic training group positioned at -11.2% fat change and +14.6% functional gain (teal marker) versus the resistance group's -6.7% and +7.4% (orange marker), linked by a dashed gray connector and overlaid with a green trend line (slope = -1.60, intercept = -3.32) yielding a perfect aggregated correlation (r = -1.00), demonstrating that aerobic interventions drive 1.67-fold greater adiposity loss and 1.97-fold enhanced endurance capacity, supported by turquoise-orange accents on a white backdrop with subtle dashed grids for precise interpretability in obesity management contexts.

DISCUSSION

The findings of this study underscore the distinct yet complementary roles of aerobic and resistance training in modulating body composition and functional fitness among obese young adults in a South Asian context, where aerobic exercise yielded superior reductions in body fat percentage (11.2%) and BMI (6.2%), alongside enhanced cardiorespiratory endurance as evidenced by greater improvements in 6MWT distance (14.6%), while resistance training promoted substantial muscle mass gains (8.8%) and modest enhancements in strength-related recovery metrics. These outcomes align with underlying physiological mechanisms, wherein aerobic training augments mitochondrial biogenesis and lipolytic pathways, facilitating sustained fat oxidation and visceral adiposity reduction through elevated post-exercise energy expenditure, whereas resistance training stimulates hypertrophic responses via increased mechanical tension and satellite cell activation, thereby preserving or augmenting lean mass during caloric deficits often associated with obesity interventions (10). The observed inverse correlation between fat loss and endurance gains, particularly pronounced in the aerobic group, further supports theoretical models of exercise-induced metabolic adaptations that enhance insulin sensitivity and mitochondrial efficiency, potentially mitigating obesity-related comorbidities such as type 2 diabetes and cardiovascular strain in this demographic (11).

Comparative analyses with prior research reveal both consistencies and nuances; for instance, our results corroborate systematic reviews indicating aerobic exercise's efficacy in clinically meaningful waist circumference and body fat reductions when sustained at moderate intensities exceeding 150 minutes weekly, yet extend these by demonstrating resistance training's relative preservation of muscle amid fat loss, contrasting older studies where weight training occasionally led to weight gain without recomposition benefits (12). Conflicts arise in contexts emphasizing combined modalities, as evidenced by trials in adolescents showing synergistic effects on total body fat and waist metrics, suggesting our single-modality design may underestimate potential additive gains, though our focus on functional outcomes advances the field by linking anthropometric shifts to practical endurance improvements, an area underexplored in South Asian cohorts where genetic predispositions to central obesity may amplify these differential responses (13). This study thus builds on longitudinal evidence from diverse populations, highlighting aerobic training's edge in fat-centric outcomes while positioning resistance as vital for countering sarcopenic risks in young obese individuals, thereby refining exercise prescription paradigms beyond Western-centric data (14).

Clinically, these differential impacts hold substantial relevance for personalized obesity management, as improved body composition via aerobic training could lower cardiometabolic risks through reduced ectopic fat deposition, while resistance-enhanced muscle mass may bolster basal metabolic rates and functional independence, facilitating long-term adherence and mitigating frailty in daily activities; integrating both modalities, as implied by our correlation trends, could optimize holistic outcomes, aligning with guidelines advocating multimodal interventions to enhance quality of life and reduce healthcare burdens in resource-limited settings (15). Strengths of this investigation include its randomized design, comprehensive assessments incorporating bioimpedance and validated fitness tests, and adjustment for confounders like diet via accelerometry, ensuring robust internal validity and reproducibility in a underrepresented South Asian sample. Nonetheless, limitations such as the modest sample size (n=60) may constrain statistical power for subgroup effects, particularly by sex, while the 12-week duration limits insights into sustained adaptations, and reliance on self-reported adherence alongside potential cultural barriers to exercise in urban youth could introduce unmeasured biases, restricting generalizability beyond similar socioeconomic strata.

Future research should prioritize larger, multicenter trials incorporating combined aerobic-resistance protocols with extended follow-ups to evaluate durability of recomposition and functional gains, alongside biomarkers of inflammation and metabolic health to elucidate mechanistic pathways; additionally, exploring dose-response relationships and hybrid digital interventions tailored to South Asian lifestyles could enhance applicability, ultimately informing evidence-based guidelines that promote equitable access to exercise therapies for obesity prevention and rehabilitation (16).

CONCLUSION

This comparative study demonstrates that aerobic training significantly reduces body fat percentage (11.2%) and BMI (6.2%) while enhancing cardiorespiratory endurance (14.6% increase in 6MWT distance), whereas resistance training markedly increases muscle mass (8.8%) and supports strength-related functional improvements among obese young adults in a South Asian context, highlighting tailored exercise modalities as critical for optimizing body composition and functional fitness in obesity management; these findings advocate for integrating both approaches in clinical practice to mitigate cardiometabolic risks and enhance quality of life, urging future research to explore long-term multimodal interventions to sustain these benefits across diverse populations (17).

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