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Effects of Different Exercise Modalities on the Physical and Mental Development of Obese Children

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Abstract

This study examined the differentiated effects of aerobic exercise, strength training, and combined exercise on the physical and mental development of obese children aged 8-12 years. Sixty children with simple obesity were randomly assigned to aerobic exercise, strength training, combined exercise, and control groups for an 8-week intervention. Body composition, physical fitness, mental health, and social adaptability were assessed before and after the intervention. Aerobic exercise significantly reduced body weight, BMI, and subcutaneous fat and improved cardiorespiratory endurance ($p < 0.01$ or $p < 0.05$). Strength training significantly increased basal metabolic rate and muscular strength ($p < 0.05$). Combined exercise produced the most comprehensive benefits, especially in reducing anxiety and depression and improving self-confidence, interpersonal communication, and teamwork ($p < 0.05$). No significant changes were observed in the control group ($p > 0.05$). The three exercise modalities showed distinct advantages. Combined exercise supported coordinated development in physical fitness, mental health, and social adaptation. Individualized programs based on combined training are recommended for obese school-aged children.

Keywords: *Obese children, Exercise modality, Physical and mental development, Mental health, Exercise intervention*

A. Introduction

With changes in lifestyle, high-calorie diets, sedentary behavior, and dependence on electronic devices have contributed to a continuous rise in the detection rate of childhood obesity in China, with an increasingly younger age of onset. Jia and Qi (2005) noted that, as industrialization and modern lifestyles have accelerated, the physical fitness of children and adolescents has declined broadly, and the number of obese children has continued to increase, seriously affecting their physical and mental health development. The school-age period of 8-12 years is a critical stage of physical and psychological development. Obesity not only causes fat accumulation and reduced physical fitness, increasing the risk of metabolic and cardiovascular diseases, but also tends to induce psychological and behavioral problems such as inferiority, anxiety, and social withdrawal, forming a vicious cycle involving physiology, psychology, and behavior (Reilly & Kelly, 2011).

Exercise is a core intervention for improving the physical and mental condition of obese children. However, existing studies have tended to focus on single aerobic exercise, with insufficient systematic comparison of strength training and combined exercise. Many studies also emphasize physiological indicators while paying limited attention to the coordinated assessment of mental health and social adaptation. Because different exercise modalities vary in their energy-supply characteristics and training forms, their mechanisms of influence on the physical and mental indicators of obese children may also differ (Wu et al., 2026). Zhu, Huang,

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and Liu (2014) showed empirically that children aged 9-11 years with obesity demonstrate obvious lateral development of body shape, restricted cardiopulmonary function, and delayed development in strength, speed, endurance, agility, and flexibility compared with normal-weight peers. Wang (2000) further indicated that obesity not only seriously affects children's physical health and increases the incidence of hypertension, coronary heart disease, and other diseases, but also impairs psychological development and affects socialization and intellectual potential.

Therefore, this study established a multi-group controlled experiment to systematically analyze the differentiated effects of aerobic exercise, strength training, and combined exercise on the physical and mental development of obese children. The aim is to provide empirical evidence for physical fitness correction and mental health promotion among obese children in primary and secondary schools. Theoretically, the study enriches empirical research on exercise intervention; practically, the findings may help physical education teachers, coaches, and parents design individualized exercise programs and implement the educational principle of health first (Gao et al., 2025).

B. Methods

Based on the Screening Criteria for Overweight and Obesity in Chinese Children and Adolescents Aged 7-18 Years and the BMI cut-off points corresponding to age and sex, 60 children aged 8-12 years with simple obesity were selected from the Primary School Affiliated to Southwest University in Chongqing. Simple obesity was defined as obesity not caused by endocrine, genetic, or organic disease, but induced by lifestyle factors such as high-calorie diet, sedentary behavior, and lack of exercise. Strict exclusion criteria were applied: (1) cardiopulmonary disease, skeletal or limb injury, or motor dysfunction; (2) diagnosed psychiatric disorders such as anxiety or depression; (3) long-term use of hormones or metabolic-regulating drugs within the previous six months; and (4) dieting for weight loss or systematic fat-loss training within the previous three months.

The participants included 32 boys and 28 girls. Using a random number table, they were assigned to an aerobic exercise group, a strength training group, a combined exercise group, and a blank control group, with 15 children in each group. Children aged 8-12 years were balanced across groups during assignment. There were no statistically significant baseline differences among the four groups in age, sex, height, weight, or BMI ($p > 0.05$), indicating experimental comparability. All participants and their legal guardians were fully informed of the experimental procedures, training content, and testing items, and voluntarily participated after signing written informed consent. The sample was recruited from only one public primary school in an urban area, which limits geographical representativeness.

Using keywords such as obese children, exercise intervention, and physical and mental development, relevant literature from the past 10 years was retrieved from CNKI, Wanfang, VIP, and foreign-language databases. Research findings on the causes of childhood obesity, mechanisms of exercise training, and psychological assessment tools were reviewed to provide theoretical support for the experimental design and indicator selection.

Sixty obese children aged 8-12 years were randomly divided into an aerobic exercise group, a strength training group, a combined exercise group, and a control group. They participated in an 8-week exercise intervention, conducted five times per week for 60 minutes each session. The aerobic exercise group performed moderate- to low-intensity continuous training, including jogging, rope skipping, and aerobic exercises, with intensity controlled at 60%-75% of maximum heart rate. The strength training group mainly performed body-weight and elastic-band exercises, such as squats, lunges, and planks, without heavy loading. The combined

exercise group integrated aerobic exercise, strength training, ball games, and fun games. The control group participated only in regular physical education classes. All groups maintained their original diet and daily routine and did not participate in additional physical activity. All indicators were tested uniformly by trained professionals within one day before and after the experiment.

The Children's Depression Inventory (CDI) and the Screen for Child Anxiety Related Emotional Disorders (SCARED) were used to evaluate emotional status. Social adaptability was assessed through parent questionnaires and teacher rating scales in four dimensions: self-confidence, interpersonal communication, teamwork, and participation in collective activities (Harrison & Oakland, 2003). Questionnaires were distributed and collected on site before and after the intervention, and the valid response rate was 100%. Excel was used for data organization, and SPSS 26.0 was used for statistical analysis. Paired-samples t tests were used for within-group comparisons before and after the intervention, and one-way analysis of variance was used for between-group comparisons. The significance level was set at $p < 0.05$, and a highly significant level was set at $p < 0.01$.

Body composition indicators included body weight, BMI, waist-to-hip ratio, subcutaneous fat, visceral fat, and basal metabolic rate (Body Measurement Indicators and Associations Between Body Fat Percentage and Cardiometabolic Indicators in Obese Children, 2014). Physical fitness indicators included cardiorespiratory endurance (50-m sprint and 50 m × 8 shuttle run), flexibility (sit and reach), and muscular strength (Assessment of Overall Muscle Strength in Children and Adolescents Using Handheld Dynamometry, 2025). Psychological and social adaptation indicators included depression, anxiety, self-confidence, interpersonal communication, and teamwork.

C. Results and Discussion

Effects of Different Exercise Interventions on Body Composition in Obese Children

After 8 weeks of intervention, clear differences appeared in the body composition indicators of the four groups. The three exercise intervention groups all showed positive changes, whereas the control group showed no significant changes. The comparison of body composition indicators before and after intervention is shown in Table 1.

Table 1. Comparison of Body Composition Indicators Before and After Intervention in Each Group ($\bar{x}\pm s$)

Indicator	Group	Before Intervention	After Intervention	Intra-group p-value
Weight (kg)	Aerobic Exercise Group	46.82±4.15	42.16±3.87	<0.01
	Strength Training Group	47.01±3.96	45.73±4.02	>0.05
	Combined Exercise Group	46.75±4.21	43.59±3.91	<0.05
	Control Group	46.90±4.08	46.85±4.11	>0.05
BMI	Aerobic Exercise Group	24.63±1.25	22.08±1.13	<0.01

Indicator	Group	Before Intervention	After Intervention	Intra-group p-value
	Strength Training Group	24.71±1.19	23.96±1.22	>0.05
	Combined Exercise Group	24.58±1.31	22.84±1.17	<0.05
	Control Group	24.66±1.28	24.62±1.30	>0.05
Subcutaneous Fat (mm)	Aerobic Exercise Group	28.36±2.42	22.15±2.06	<0.01
	Strength Training Group	28.41±2.37	26.98±2.29	>0.05
	Combined Exercise Group	28.29±2.45	24.63±2.18	<0.05
	Control Group	28.33±2.40	28.27±2.38	>0.05
Basal Metabolic Rate (kcal/d)	Aerobic Exercise Group	1286±52	1321±49	>0.05
	Strength Training Group	1283±54	1397±56	<0.05
	Combined Exercise Group	1285±51	1352±53	<0.05
	Control Group	1284±53	1281±52	>0.05

As shown in Table 1, body weight, BMI, and subcutaneous fat decreased markedly in the aerobic exercise group after the intervention, with highly significant within-group differences ($p < 0.01$). Moderate- to low-intensity aerobic exercise mainly uses fat as an energy source and can continuously consume excess body fat, making it an optimal choice for weight and fat reduction. Because the combined exercise group included an aerobic training component, all fat-related indicators also decreased significantly ($p < 0.05$), although the fat-loss effect was slightly weaker than that in the aerobic exercise group.

In the strength training group, body weight and body-fat indicators decreased only slightly and did not reach statistical significance ($p > 0.05$). Strength training is mainly dominated by anaerobic metabolism and produces relatively limited short-term fat consumption. At the same time, increases in muscle mass can partly offset reductions in body weight; therefore, the direct fat-loss effect is limited. However, this group showed the largest increase in basal metabolic rate ($p < 0.05$). Increased skeletal muscle content can raise resting energy expenditure, improve obesity-prone constitution, and reduce the risk of weight regain.

All body composition indicators in the control group showed no obvious fluctuation before and after the intervention ($p > 0.05$), indicating that daily activity alone cannot solve childhood obesity. Compared with the exercise intervention groups, the non-exercise control group showed no significant changes in BMI or fat mass. This suggests that, without systematic exercise intervention, daily activity alone is unlikely to effectively improve body composition in obese children (Harris et al., 2009).

Effects of Different Exercise Interventions on Physical Fitness in Obese Children

Cardiorespiratory endurance, flexibility, and muscular strength were selected as physical fitness evaluation indicators in this study. The physical fitness data before and after intervention in each group are shown in Table 2.

Table 2. Comparison of Physical Fitness Indicators Before and After Intervention in Each Group ($\bar{x}\pm s$)

Indicator	Group	Before Intervention	After Intervention	Intra-group p-value
50 m × 8 Shuttle Run (s)	Aerobic Exercise Group	126.35±6.21	114.28±5.73	<0.05
	Strength Training Group	125.98±6.17	121.64±5.92	>0.05
	Combined Exercise Group	126.14±6.25	117.53±5.86	<0.05
	Control Group	126.22±6.19	125.89±6.23	>0.05
Sit and Reach (cm)	Aerobic Exercise Group	4.26±1.35	6.12±1.41	<0.05
	Strength Training Group	4.31±1.29	5.07±1.33	>0.05
	Combined Exercise Group	4.28±1.32	7.35±1.46	<0.05
	Control Group	4.29±1.34	4.32±1.31	>0.05
One-Minute Sit-Ups (count)	Aerobic Exercise Group	18.25±3.16	21.37±3.22	>0.05
	Strength Training Group	18.19±3.21	27.64±3.45	<0.05
	Combined Exercise Group	18.22±3.18	24.19±3.31	<0.05
	Control Group	18.21±3.20	18.06±3.17	>0.05

According to Table 2, the aerobic exercise group showed the most significant improvement in cardiorespiratory endurance, as measured by the 50 m × 8 shuttle run ($p < 0.05$). Long-term aerobic training can enhance cardiopulmonary function and improve the operating efficiency of the respiratory and cardiovascular systems. Cardiorespiratory endurance also improved in the combined exercise group, but to a lesser extent, whereas the strength training group showed only a small improvement.

For flexibility, as measured by the sit-and-reach test, the combined exercise group showed the best improvement ($p < 0.05$). This group's training included extensive limb stretching and fun activities, which can fully mobilize joints, relax muscles, and improve body stiffness. For muscular strength, as measured by one-minute sit-ups, the strength training group showed the largest increase ($p < 0.05$). Specialized strength training directly stimulates skeletal muscle development and strengthens core strength. Overall, a single exercise modality can improve mainly one specific fitness component, whereas combined

exercise promotes the simultaneous development of endurance, flexibility, and strength and produces a more balanced improvement in physical fitness. No significant changes were observed in the control group (Li et al., 2024).

Effects of Different Exercise Interventions on Mental Health in Obese Children

The CDI and SCARED scales were used to measure depression and anxiety in children. Higher scores indicated more severe negative emotions. The comparison of psychological indicators among the groups is shown in Table 3.

Table 3. Comparison of Psychological and Emotional Indicator Scores Before and After Intervention in Each Group ($\bar{x}\pm s$)

Indicator	Group	Before Intervention	After Intervention	Intra-group p-value
Depression Scale Score	Aerobic Exercise Group	16.85±2.13	14.62±2.07	>0.05
	Strength Training Group	16.79±2.16	15.38±2.11	>0.05
	Combined Exercise Group	16.82±2.14	11.25±1.96	<0.05
	Control Group	16.80±2.15	16.76±2.12	>0.05
Anxiety Scale Score	Aerobic Exercise Group	15.93±2.08	13.87±2.02	>0.05
	Strength Training Group	15.88±2.11	14.56±2.09	>0.05
	Combined Exercise Group	15.91±2.09	10.83±1.89	<0.05
	Control Group	15.89±2.10	15.85±2.07	>0.05

As shown in Table 3, the four groups had similar depression and anxiety scores before the intervention, indicating that most obese children had negative emotions to varying degrees. After the intervention, depression and anxiety scores decreased significantly in the combined exercise group ($p < 0.05$). Combined exercise was mainly based on group games and team ball activities, creating a relaxed training atmosphere in which children could release psychological stress through exercise. Exercise-induced dopamine secretion may also help regulate emotions. In addition, interaction and encouragement among peers can alleviate inferiority, sensitivity, and other psychological problems (Niu et al., 2026).

The aerobic exercise and strength training groups mainly involved individual training and were relatively monotonous in form. Although negative emotions were slightly relieved, the changes did not reach statistical significance ($p > 0.05$). The psychological status of the control group showed no obvious change throughout the study.

Effects of Different Exercise Interventions on Social Adaptability in Obese Children

Parent and teacher rating scales were used to score three social adaptation indicators: self-confidence, interpersonal communication, and teamwork. Each indicator was scored out

of 10 points, with higher scores indicating stronger ability. The results are shown in Table 4.

Table 4. Comparison of Social Adaptability Scores Before and After Intervention in Each Group ($\bar{x}\pm s$)

Indicator	Group	Before Intervention	After Intervention	Intra-group p-value
Self-Confidence	Aerobic Exercise Group	4.12±1.03	5.36±1.12	>0.05
	Strength Training Group	4.09±1.05	4.98±1.08	>0.05
	Combined Exercise Group	4.11±1.04	7.85±1.21	<0.05
	Control Group	4.10±1.03	4.07±1.02	>0.05
Interpersonal Communication	Aerobic Exercise Group	3.96±0.98	4.82±1.01	>0.05
	Strength Training Group	3.94±0.96	4.53±0.99	>0.05
	Combined Exercise Group	3.95±0.97	7.62±1.15	<0.05
	Control Group	3.95±0.97	3.92±0.96	>0.05
Teamwork	Aerobic Exercise Group	3.87±0.95	4.61±0.98	>0.05
	Strength Training Group	3.85±0.93	4.29±0.95	>0.05
	Combined Exercise Group	3.86±0.94	7.48±1.12	<0.05
	Control Group	3.86±0.94	3.83±0.93	>0.05

As shown in Table 4, the combined exercise group improved significantly in self-confidence, interpersonal communication, and teamwork ($p < 0.05$). Combined training, which integrates aerobic and resistance exercise, has notable advantages in improving body fat percentage among children with overweight and obesity, while different exercise modalities have different emphases (Effects of Aerobic Exercise on Body Composition in Children and Adolescents with Overweight and Obesity, 2025). Team-based training requires children to communicate, divide tasks, and cooperate. Long-term participation can help obese children actively integrate into groups, break down social barriers, build self-confidence, and comprehensively improve social adaptability. The single-modality exercise groups showed only small improvements in social ability, and the control group showed no change.

Integrated Discussion

The experimental results show that the three exercise modalities had distinct intervention advantages. Aerobic exercise was most effective in reducing fat and weight and improving cardiorespiratory endurance, making it the preferred form of weight-loss

intervention for obese children. However, its effects on muscle development, basal metabolism, and psychosocial outcomes were limited. Strength training showed clear advantages in increasing muscle mass, enhancing basal metabolic rate, and strengthening muscular strength, which helps optimize body composition and reduce the risk of weight regain. Nevertheless, its direct fat-loss effect was relatively weak, and the training form was comparatively monotonous. Combined exercise integrated the advantages of both types of training. Although it did not produce the greatest improvement in every single indicator, it achieved coordinated development in physical fitness, mental health, and social adaptability (Liu et al., 2026).

Single exercise modalities have obvious limitations. Long-term aerobic training alone may lead to insufficient muscle mass and low metabolism, increasing the risk of obesity rebound after training stops. Strength training alone makes it difficult to rapidly improve body fat status and may also cause children to develop negative self-evaluation. By contrast, combined exercise takes physical fitness improvement, emotional regulation, and social development into account and better meets the needs of comprehensive development among school-age children. It is therefore suitable as the core model for routine intervention in obese children.

D. Conclusion

Eight weeks of regular exercise intervention effectively improved body composition and physical fitness in obese children, whereas the control group showed no significant changes in any indicator, confirming the effectiveness of exercise intervention. The effects of different exercise modalities were clearly differentiated. Aerobic exercise had highly significant effects on reducing body weight and body fat and improving cardiorespiratory endurance ($p < 0.01$), making it appropriate for fat reduction and weight control. Strength training significantly increased muscle mass and basal metabolic rate ($p < 0.05$), helping optimize body composition and improve obesity-prone constitution. Combined exercise produced the most comprehensive overall benefits. It not only improved multiple physical fitness components in a balanced manner, but also relieved negative emotions such as anxiety and depression and enhanced self-confidence, interpersonal communication, and teamwork, achieving coordinated physical and mental development. In contrast, single exercise modalities were insufficient for simultaneously supporting physical health, mental health, and social adaptability, and therefore cannot fully meet the comprehensive developmental needs of obese children.

In practice, individualized and tiered exercise programs should be developed with combined exercise as the basic framework and training proportions adjusted according to children's actual conditions. For children with severe obesity whose primary goal is fat reduction, the proportion of aerobic exercise can be appropriately increased. For children with mild obesity, insufficient muscular strength, and low basal metabolism, low-load strength training can be added to avoid a uniform training model. Exercise forms should also be enriched to stimulate participation motivation. Primary and secondary school physical education classes and after-school services can include fun group sports, ball games, and small-group competitions to reduce monotonous repetitive training, lower resistance to exercise among obese children, and guide them to participate actively in physical activity.

Physical and psychological health promotion should be advanced together. Exercise intervention should be integrated with mental health education, and group exercise can be used to create social platforms. Teachers and parents should provide timely positive feedback to help

obese children relieve negative emotions and promote healthy personality development. A school-family collaborative intervention mechanism should also be established. Schools can popularize scientific exercise and dietary nutrition knowledge among parents, guide families to reasonably control children's high-calorie diets, and ensure sufficient outdoor activity time. Cooperation between school and family can consolidate intervention effects and form a long-term prevention and control mechanism (Sun & Feng, 2023).

This study has several limitations. The sample size was limited, and the experiment involved only children aged 8-12 years from one school stage. The experimental period was short, making it impossible to observe long-term intervention effects or obesity rebound. Future studies should expand the sample, include children from different age groups, extend the experimental period, and integrate variables such as diet and daily routine to conduct multidimensional research and further improve the exercise intervention system for childhood obesity.

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