Effects of Parental Involvement Via Fitness Application on Weight Loss and Physical Activity among Overweight and Obese Adolescents in China: A Pilot Study

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Abstract—**The rising prevalence of childhood and adolescent obesity in China calls for effective intervention strategies, and while parental involvement is recognized as a key modifiable factor in youth weight management, its efficacy when delivered via digital fitness applications remains underexplored. This pilot study therefore, aimed to evaluate the effects of a Parental Involvement Fitness Application (PIFA) compared with an Individual Fitness Application (IFA) on weight loss and physical activity among overweight and obese adolescents. An eight-week, two-arm pilot cluster-randomized controlled trial was conducted in Jiaozuo City, Henan Province, enrolling 28 adolescents aged 12–15 years with a Body Mass Index (BMI) percentile above 85. Participants were randomized at the school level to either the PIFA group (n = 13), who engaged in structured parent-child co-exercise through the app, or the IFA group (n = 14), who used the app independently. Primary outcomes were BMI, Waist-to-Hip Ratio (WHR), and Physical Activity Level (PAL) measured by the PAQ-CN questionnaire, and data were analysed using Generalized Estimating Equations (GEE) with post-hoc pairwise comparisons. Baseline characteristics were comparable between groups. Although time exerted a significant main effect on all three outcomes ($p < 0.001$), a significant group-by-time interaction emerged only for PAL ($\chi^2 = 78.051, p < 0.001$), favouring the PIFA group. Post-test PAL scores were significantly higher in the PIFA group than in the IFA group ($p < 0.001$) with a large effect size (d = 0.78), whereas no between-group differences were observed for changes in BMI or WHR over time. These findings indicate that an eight-week intervention using a parental involvement fitness application significantly improves physical activity levels among overweight and obese adolescents compared to individual app use, although it does not lead to short-term changes in BMI or WHR. The results suggest that digitally mediated parental co-engagement is a promising strategy for promoting physical activity behaviour in youth and warrants further investigation in larger, longer-term trials that incorporate dietary components.**

Keywords—**fitness application, parental involvement, physical activity, obesity intervention, cluster RCT**

I. Introduction

The Global Burden of Disease Study Obesity Collaborative Group conducted a statistical analysis of the obese population in 195 countries around the world from 1980 to 2015. The results showed that a total of 107.7 million children were obese, and the growth rate of obesity in children was faster than that in adults [1]. The rapid spread of obesity has been facilitated by shifts in nutrition and physical activity behaviours as a result of rapid economic development in the Asian region.

China is currently undergoing an economic transition. People's lifestyles, living environment and health awareness are constantly changing. The resulting health problems deserve attention. Obesity has become a major public health issue in China. Overweight and obesity have increased rapidly in the past four decades, and the latest national prevalence estimates for 2015–2019, based on Chinese criteria, were 6.8% for overweight and 3.6% for obesity in children younger than 6 years, 11.1% for overweight and 7.9% for obesity in children and adolescents aged 6–17 years, and 34.3% for overweight and 16.4% for obesity in adults (≥ 18 years). Strong evidence from prospective cohort studies has linked overweight and obesity to increased risks of major non-communicable diseases and premature mortality in Chinese populations. The growing burden of overweight and obesity could be driven by economic developments, sociocultural norms, and policies that have shaped individual-level risk factors for obesity through urbanization, urban planning and built environments, and food systems and environments [2]. The prevalence of these health problems is on the rise as Chinese youth adopt different dietary patterns and reduce their physical activity [3]. Urbanization, a sedentary lifestyle, and a shift to a Westernised diet rich in processed foods and sugary drinks have all contributed to rising obesity rates among Chinese adolescents [4].

By examining the role of digitally-mediated parental co-engagement, this study contributes to the social science literature on family-based health interventions in three key ways. First, it provides empirical evidence on how digital platforms can reshape parent-child dynamics and collective health behaviours within the home environment. Second, it explores the socio-behavioral mechanisms—such as motivation, accountability, and shared activity—that underpin the effectiveness of technology-driven weight management programs. Finally, the findings offer practical insights for policymakers and educators in China seeking scalable, socially embedded strategies to address the rising prevalence of adolescent obesity, highlighting the intersection of technology, family structure, and public health.

II. Literature Review

A. Adolescent Obesity: Prevalence and Health Implications

The rising prevalence of adolescent obesity has become a significant public health challenge globally, with particularly concerning trends observed in China. Worldwide, obesity rates among children and adolescents aged 5 to 19 years increased dramatically from 1975 to 2016, with prevalence rising from 0.7% to 5.6% for girls and from 0.9% to 7.8% for boys [5]. This pattern shows marked regional variation, with rates exceeding 30% in numerous Pacific Island nations and surpassing 20% in several countries across the Middle East, North Africa, and the Americas [5]. The World Obesity Federation projects that by 2030, approximately 254 million children and adolescents aged 5 to 19 years will have obesity, with China, India, and the USA expected to have the highest absolute numbers [6].

China is currently undergoing rapid economic transition, accompanied by significant shifts in nutrition, physical activity behaviours, and living environments [3]. Based on Chinese criteria, the latest national prevalence estimates for 2015–2019 indicate that 11.1% of children and adolescents aged 6–17 years are overweight and 7.9% are obese, with even higher rates among adults [2]. Urbanization, sedentary lifestyles, and the adoption of Westernised diets rich in processed foods and sugary drinks have all contributed to these rising trends [4, 7]. The COVID-19 pandemic further exacerbated this situation, with research in China, Europe, and the USA reporting significant weight gain among children and adolescents compared to pre-pandemic levels, attributed to decreased physical activity, increased screen time, and disrupted routines [8–10].

The health consequences of adolescent obesity are severe and multifaceted. Evidence indicates that children who are overweight upon entering kindergarten are nearly four times more likely to develop obesity by junior high school age [11]. Obese children face an elevated risk of developing chronic health conditions, including cardiovascular diseases, type 2 diabetes, and certain cancers, at an earlier age, potentially leading to a shorter life expectancy than their parents' generation [12–15]. A childhood diagnosis of obesity is considered a strong predictor of adult obesity status [16, 17].

Beyond physical health, obesity significantly impacts psychosocial development during this critical period characterized by heightened independence from parents, peer acceptance, and identity formation [18]. Overweight adolescents are frequently victimized by peers and exhibit elevated levels of low self-esteem, depression, anxiety, and loneliness compared to their normal-weight counterparts [19, 20]. Some adolescents experience depressive symptoms and increased risk of suicidal ideation when exposed to weight-related taunting [21]. Increased body awareness and appearance concerns represent distinct obstacles to physical activity participation for overweight adolescents compared to their non-overweight peers [22, 23]. These barriers differ substantially from those faced by normal-weight individuals, necessitating targeted intervention approaches [24].

B. Factors Influencing Physical Activity Participation Among Overweight and Obese Adolescents

Multiple interrelated factors contribute to overweight and obesity, creating a multifaceted condition that extends beyond simple energy imbalance. Ecological models indicate that risk factors encompass nutritional intake, physical activity patterns, and sedentary behaviour, all influenced by environmental and societal determinants including family attributes, parental lifestyles, governmental policies, and screen culture [25, 26]. Substantial evidence correlates obesity with high consumption of energy-dense, nutrient-poor foods—such as soft drinks, savoury snacks, and confectionery—combined with increased sedentary time [27, 28]. Research among Australian adolescents found that approximately 51% of boys and 43% of girls exhibited three or more behavioural risk factors for obesity, including insufficient physical activity, excessive screen time, poor diet, and high consumption of soft drinks and snacks [29].

For overweight and obese adolescents specifically, participation in physical activity presents unique challenges. Studies consistently demonstrate that these youth exhibit greater sedentary behaviour and reduced physical activity compared to their normal-weight counterparts [30]. Weight-related victimization creates additional psychological barriers, as adolescents who are overweight often experience teasing and social marginalization that discourage active participation in physical activities [31]. The stigma associated with obesity can lead to body dissatisfaction, reduced self-efficacy, and avoidance of exercise settings where they might face judgment or comparison [32]. These psychosocial barriers must be addressed alongside environmental and behavioural factors to effectively promote physical activity engagement [33].

C. The Role of Parental Involvement in Adolescent Weight Management

Considerable empirical evidence supports incorporating parental and family involvement in multicomponent behavioural interventions for child and adolescent weight management [34–36]. The family involvement approach is essential because children's weight-related behaviours are primarily exhibited within the home context and significantly influenced by parental modelling [37]. Parents can affect the adoption of healthy behaviours and weight status through their own actions and the environments they create [38]. The US Preventive Services Task Force emphasizes that family involvement highlights the ability of parents to influence their children's behavioural change [39].

Family-Based Treatment (FBT) represents the gold standard in paediatric weight management interventions, distinguished by significant parental participation in treatment alongside their children [34, 40]. Within the FBT framework, parents simultaneously pursue personalized lifestyle improvements for themselves while serving as change agents for their children, a dynamic particularly vital for treatment efficacy [41, 42]. Parental weight loss is identified as the primary predictor of weight reduction in children, underscoring the importance of active parental engagement [40]. The Endocrine Society Clinical Practice Guidelines and Expert Committee Recommendations universally recognize family-based approaches as the preferred intervention strategy [38, 41].

The mechanisms through which parental involvement operates are multifaceted. Positive parental influence, including encouragement, modelling, and instrumental support, is significantly associated with higher moderate-to-vigorous physical activity among children and adolescents [43, 44]. Parental co-activity during COVID-19 lockdown conditions nearly doubled the odds of adolescents maintaining or increasing their activity levels [45].

Meta-analytic evidence confirms a significant positive association between parental influence and children's physical activity levels, with pooled effect sizes ranging from moderate to substantial [46, 47]. However, the quality and nature of parental involvement matter considerably; supportive behaviours that respect adolescent autonomy are more effective than controlling or directive approaches [48].

D. Digital Interventions for Adolescent Obesity: Fitness Applications

Fitness applications have undergone significant evolution over the past two decades, driven by technological advancement and changing health behaviours [49]. The development can be examined across four distinct phases: foundational technologies and early tracking (2005–2010) with basic GPS and accelerometer functionality; smartphone ubiquity and ecosystem expansion (2011–2014) featuring diversified apps and social integration; wearable integration and AI personalization (2015–2019) enabling continuous biometric monitoring; and pandemic acceleration with immersive technologies (2020–present) incorporating virtual reality and hybrid offerings [50–52].

Fitness apps offer considerable benefits for adolescent growth and development. They provide convenient access to exercise routines, nutritional guidance, and social support networks that foster positive health behaviours [53, 54]. For physical health, these apps encourage regular structured exercise, leading to improvements in cardiovascular fitness, muscular strength, and flexibility [55, 56]. Psychologically, app-guided exercise can reduce stress, improve mood, enhance sleep quality, and boost self-esteem through mechanisms including elevated brain-derived neurotrophic factor and gamified achievement systems that foster self-efficacy [57–60]. Behaviourally, fitness apps embed evidence-based behaviour change techniques such as self-monitoring, goal setting, personalized feedback, and social support features that promote long-term adherence and habit formation [61–63].

However, empirical evidence reveals mixed findings regarding app effectiveness among adolescents. While some studies report significant increases in physical activity and improvements in body composition following app-based interventions [64, 65], others find limited or short-lived effects, particularly for psychological and social outcomes [66–68]. Sustained engagement remains a persistent challenge, with studies noting declining usage post-intervention and underscoring the need for designs supporting long-term habit formation [69]. Methodologically, many app-based studies rely on short intervention durations, small convenience samples, and self-reported measures, raising concerns about measurement bias and generalizability [70–72]. Moreover, most fitness applications are designed primarily for adult users and may not adequately address adolescents' developmental needs, social contexts, or reliance on external support structures [73, 74].

E. Integration of Parental Involvement and Digital Interventions

The integration of parental involvement with digital fitness interventions represents a promising but underexplored approach. Digitally-mediated parental co-engagement has the potential to reshape parent-child dynamics and collective health behaviours within the home environment [75]. By leveraging fitness apps as platforms for shared physical activity, parents can provide the emotional encouragement, accountability, and social reinforcement that adolescents need to sustain motivation and adherence [76, 77]. The structured, joint exercise sessions offered through apps like Keep can operationalize the principles of the Health-Related Fitness Model, targeting multiple fitness components while strengthening family bonds [78, 79].

Conceptual frameworks for understanding adolescent well-being increasingly adopt a multidimensional perspective encompassing physical, psychological, and social domains [80, 81]. Within educational research, well-being is treated as integral to adolescents' learning experiences, identity formation, and social participation within school and family contexts [82, 83]. Physical well-being provides foundational capacity for daily activities; psychological well-being supports motivation, confidence, and resilience; and social well-being facilitates meaningful relationships and a sense of belonging within key developmental contexts [84–86]. The Health-Related Fitness Model posits that improvements in physical fitness components achieved through regular activity contribute to better health outcomes across these dimensions [79].

Parental involvement in adolescents' daily routines, including shared physical activity, has been associated with emotional support, behavioural regulation, and modelling of health-related values [75, 87]. Such involvement is particularly salient during early adolescence when parental influence remains substantial despite increasing peer orientation [88]. Accordingly, parental involvement positioned as a key contextual factor differentiating intervention conditions may enhance adolescent engagement and consistency in physical activity routines through social reinforcement and shared enjoyment [45].

F. Research Gaps and the Present Study

Critical examination of existing literature reveals several significant gaps. First, while fitness apps and parental involvement have individually demonstrated effectiveness, empirical evidence on the efficacy of their combination as an integrated digital intervention remains extremely limited, particularly for adolescent populations in non-Western contexts. Second, a substantial proportion of existing research is conducted in Western countries and clinical or community health settings, with far fewer investigations situated in school-aged populations within East Asian educational environments [89]. This Western bias limits applicability to contexts where cultural norms surrounding parenting, autonomy, and physical activity differ substantially [90]. Third, methodological weaknesses pervade the literature, including short intervention durations, small sample sizes, reliance on self-reported measures, and inadequate control for clustering effects in school-based research [70–72]. Fourth, many studies focus narrowly on anthropometric outcomes without a comprehensive assessment of multidimensional well-being, including psychological and social dimensions critical for adolescent development [73, 74].

The present pilot study addresses these gaps by evaluating the effects of a Parental Involvement Fitness Application (PIFA) compared to an Individual Fitness Application (IFA) on physical, psychological, and social well-being outcomes among overweight and obese adolescents in China. Grounded in the Health-Related Fitness Model and employing a cluster-randomized controlled trial design, this research provides empirical evidence on whether digitally-mediated parental co-engagement can serve as a more effective strategy for promoting positive health behaviours and overall well-being than app use alone. The findings contribute to the social science literature on family-based health interventions and offer practical insights for policymakers and educators seeking scalable, socially embedded strategies to address the rising prevalence of adolescent obesity in China.

III. Methods

A. *Study Design*

This pilot study employs a cluster-randomised controlled trial using a 2-week repeated measures design. A quantitative approach is adopted to investigate the impact of parental involvement via fitness applications on the well-being of overweight and obese junior high school students (aged 12–15 years) in Jiaozuo City, Henan Province. Participants were randomly assigned at the school level to one of two groups: the Parental Involvement Fitness App (PIFA) group or the Individual Fitness App (IFA) group.

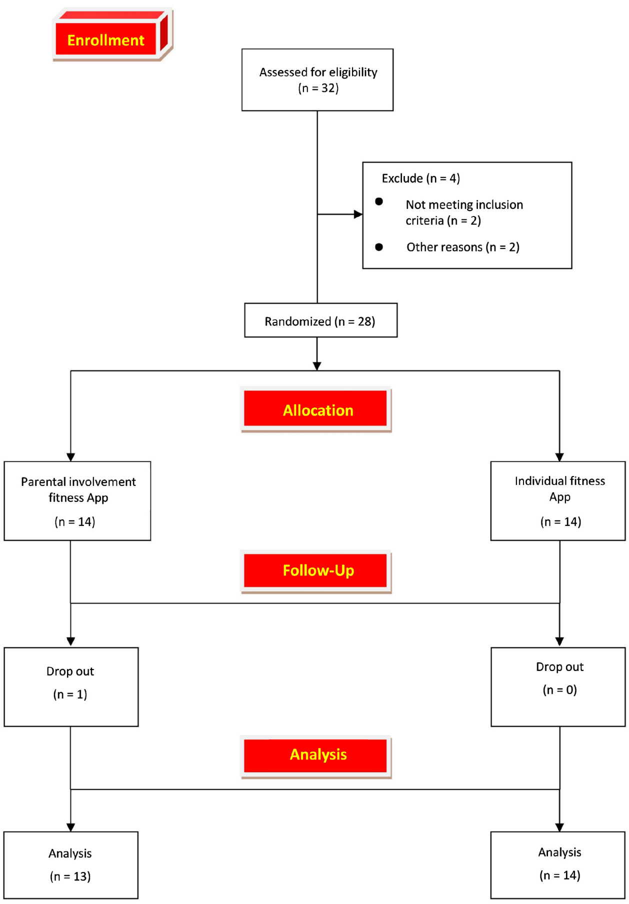

Fig. 1. CONSORT 2010 flow diagram.

The CRCT design is particularly appropriate for this research as it minimises contamination between groups. Since students within the same school are likely to share environments, interactions, and influences, randomising at the school level ensures that each school operates as an independent cluster. This approach reduces cross-group contamination and enhances the reliability of the intervention's outcomes. All methods were performed in accordance with the relevant guidelines and regulations, and the reporting of this cluster randomised trial follows the CONSORT 2010/2025 guidelines (Fig. 1).

B. *Participants*

Eligibility Criteria:

Inclusion: (1) The family has a mobile phone connected to the Internet; (2) The age of the experimental subjects should be 12-15 years old; (3) Ensure that at least one parent has enough time to accompany the child to complete the experimental task within a week ; (4) The BMI percentile should be greater than 85; (5) There is no other exercise except for daily physical activities; (6) The parents of the subjects agree that their children will participate in the experiment and are willing to participate with their children.

Exclusion: (1) clinically diagnosed with mental illness; (2) clinically diagnosed with chronic disease; (3) taking related weight loss drugs within half a year; (4) Single-parent family; (5) contradictions to PA participation as determined by PAR-Q responses.

C. *Outcome Measures*

1) *Body Mass Index (BMI)*

BMI is a widely used indicator for assessing body fat based on a person's weight in relation to height. In this study, the BMI of participants was calculated using the standard formula: BMI = weight (kg)/[height (m)]^2. Body weight was measured using a calibrated digital weighing scale, and standing height was measured with a portable stadiometer. Participants were asked to remove their shoes and wear light clothing during measurement. Height was recorded to the nearest integer centimetre, and weight to the nearest 0.1 kilogram. The BMI values were calculated and rounded to two decimal places. The categorisation of overweight and obesity was based on the Screening for Overweight and Obesity Among School-age Children and Adolescents (WS/T 586–2018), a national standard in China issued by the National Health Commission. This guideline provides age- and sex-specific BMI thresholds for identifying overweight and obese status in children and adolescents.

2) *Waist-to-Hip Ratio (WHR)*

Waist-to-hip ratio (WHR) is a widely used anthropometric indicator for evaluating fat distribution and identifying central obesity, which is particularly relevant to cardiometabolic health risks. In this study, WHR was calculated using the formula: WHR = waist circumference (cm)/hip circumference (cm). Waist circumference was measured at the narrowest point between the lower margin of the last palpable rib and the iliac crest, while hip circumference was measured at the widest point of the buttocks. A non-stretchable, flexible measuring tape was used, and all measurements were recorded to the nearest 0.1 centimetre. Each measurement was taken twice, and the average value was used to enhance reliability. The final WHR value was calculated and retained to two decimal places for consistency and precision in data analysis. This method adheres to standard anthropometric procedures for adolescents and is appropriate for use in health research involving obesity-related indicators.

3) Physical Activity Level PAL

In this study, the PAQ-CN questionnaire developed by Guo Qiang was used to collect data on PA, including leisure time sports, daily PA after school, PA in a physical education class, and more than 30-minute activities [91]. Including: the basic information and investigation contents of the respondents, including 9 questions; covering physical activity frequency, content, and intensity, which are assigned 5-points Likert scale (1 to 5). The total score is the sum of the average score of the first question (22 sub-questions) and the ninth question (7 sub-questions), plus the scores of the other questions. The higher the total score, the higher the physical activity level of the respondents. The questionnaire was also found to have good correlations, Cronbach's α is 0.821 [91].

D. Outcome Measures

A generalized estimating equation (GEE) model was used to evaluate intervention programs' effectiveness on dependent variables. GEE extends the logistic regression model to allow for clustering [92]. This thesis illustrates the analysis of longitudinal data on BMI, waist-to-hip ratio, and physical activity level among overweight and obese adolescents using GEE under various intervention correlation assumptions.

IV. Result and Discussion

A. Participant Flow and Baseline Characteristics

Of 32 eligible students, 28 (87.5 %) completed the trial (PIFA: n = 13, IFA: n = 14). Baseline characteristics demonstrated no significant between-group differences in BMI percentile (p = .29), WHR (p = .16), and PAL (p = .74), confirming successful randomization (Table 1).

Table 1. Mean comparison among groups for research variables in pre-test (mean, SD)

Variables	PIFA	IFA	*F*-value	*P*-value
	n = 44	*n* = 43		
BMI	25.21 (1.41)	25.36 (1.40)	2.02	0.29
WHR	0.81 (0.001)	0.83 (0.002)	1.55	0.16
PAL	12.58 (1.52)	12.49 (1.48)	0.22	0.74

B. Evaluating the Effectiveness of the Fitness Application Intervention on BMI, WHR, and PAL between Groups

The effects of PIFA and IFA on physical well-being variables were observed through BMI, Waist-to-Hip Ratio (WHR), and Physical Activity Level (PAL). Descriptive data (mean and standard error) for BMI, WHR, and PAL level are shown in Table 2.

Table 2. Descriptive statistics (mean and SE) of BMI, WHR, and PAL between groups across time

Variables	Time	PIFA	IFA
BMI	Pre-test	25.21 (0.212)	25.36 (0.154)
	Post-test	25.48 (0.222)	25.16 (0.149)
WHR	Pre-test	0.81 (0.005)	0.83 (0.007)
	Post-test	0.81 (0.008)	0.82 (0.008)
PAL	Pre-test	12.58 (0.222)	12.49 (0.225)
	Post-test	14.26 (0.208)	13.21 (0.210)

The group's main effect on the level of BMI (χ^2 = 2.25, p = 0.229) was not statistically significant. However, the effect of time on BMI was significant (χ^2 = 132.25, p < 0.001). Notably, the interaction effect between groups and time (group×time) on BMI was not statistically significant (χ^2 = 2.126, p = 0.121), showing that groups had no significant differences over time.

The group's main effect on the level of WHR (χ^2 = 0.082, p = 0.821) was not statistically significant. However, time had a significant influence on WHR (χ^2 = 412.508, p < 0.001). Notably, the interaction between groups and time (group×time) on WHR was not statistically significant (χ^2 = 0.889, p = 0.474), showing that groups had no significant differences over time.

The group's main effect on the level of PAL (χ^2 = 2.584, p = 0.082) was statistically significant. Meanwhile, time had a significant influence on PAL (χ^2 = 437.294, p < 0.001). Notably, the interaction between groups and time (group×time) on PAL was statistically significant (χ^2 = 78.051, p < 0.001), showing that groups had significant different patterns over time. The details are shown in Table 3.

Table 3. Results of GEE on BMI, WHR, and PAL score

Variables	Source	Wald Chi-Square	df	*p*-value
BMI	Group	2.25	1	0.229
	Time	132.25*	1	< 0.001
	Time×Group	2.126	1	0.121
WHR	Group	0.082	1	0.821
	Time	412.508*	1	< 0.001
	Time×Group	0.889	1	0.474
PAL	Group	2.584*	1	0.082
	Time	437.294*	1	< 0.001
	Time×Group	78.051*	1	< 0.001

The mean difference is significant at the*.

In order to determine the differences in BMI, WHR, and PAL between two groups of overweight and obese adolescents across time, the post hoc test (Bonferroni) was applied (Table 4). For BMI, there were statistically significant changes (p < 0.001) in the PIFA and IFA groups between two different times (pre-test and post-test). The results of the effect size indicated that time had a small effect size in the PIFA group (d = 0.22) and IFA (d = 0.23).

For WHR, there were statistically significant changes (p < 0.001) in the PIFA and IFA groups between two different times (pre-test and post-test). The results of the effect size indicated that the time had a large effect size in the PIFA group (d = 2.41) and IFA (d = 2.35).

For PAL, there were statistically significant changes (p < 0.001) in the PIFA and IFA groups between two different times (pre-test and post-test). The results of the effect size indicated that time had a small effect size in the PIFA group (d = 1.18) and a medium effect size in the IFA (d = 0.58).

Table 4. Pairwise Comparison of BMI, WHR, and PAL Mean Score across Time for Two Groups

Variables	Groups	Mean Difference (Pre-Post)	SE	*p*-value	95% CI		Effect Size (d)
					Lower	Upper	
BMI	PIFA	0.298	0.035*	< 0.001	0.205	0.401	0.22
	IFA	0.254	0.046*	< 0.001	0.184	0.425	0.23
WHR	PIFA	0.023	0.009*	< 0.001	0.016	0.167	2.41
	IFA	0.034	0.009*	< 0.001	0.015	0.025	2.35
PAL	PIFA	−1.617	0.078*	< 0.001	−2.078	−1.538	1.18
	IFA	−0.579	0.034*	< 0.001	−0.825	−0.610	0.58

The mean difference is significant at the*.

The post hoc (Bonferroni) test was applied to compare the mean value. The results are summarised in Table 5. For BMI, at the pre-tests and post-tests, comparisons between groups indicated no significant difference ($p = 0.452$, $p = 0.252$). The effect size was calculated between groups at two different times (pre-test and post-test); the results indicate that there was a small effect size, $d = 0.28$, at pre-test, as well as a small effect size, $d = 0.31$, at post-test.

For WHR, no significant differences were seen between groups at the pre-test and post-test ($p = 0.782$). The effect size results indicated a small effect size, $d = 0.25$ at pre-test, as well as a small effect size, $d = 0.28$ at post-test.

For PAL, there were no significant changes between PIFA and IFA at pre-test. The effect size results indicated a small effect size, $d = 0.06$ at pre-test. However, there was a significant difference ($p < 0.001$) between two groups at post-test. The effect size result indicated a large effect size, $d = 0.78$ at post-test.

Table 5. Pairwise comparison among groups at pre-test and post-test for BMI, WHR, and PAL

Variables	Time	Between Groups	Mean Difference	*p*-value	95% CI		Effect Size (d)
					Lower	Upper	
BMI	Pre-test	PIFA vs IFA	0.452	0.252	−0.165	1.091	0.28
	Post-test	PIFA vs IFA	0.362	0.321	−0.242	0.958	0.31
WHR	Pre-test	PIFA vs IFA	−0.001	0.782	−0.003	0.001	0.25
	Post-test	PIFA vs IFA	0.002	0.825	−0.002	0.003	0.28
PAL	Pre-test	PIFA vs IFA	0.116	0.706	−0.488	0.720	0.06
	Post-test	PIFA vs IFA	1.155	< 0.001*	0.445	1.863	0.78

The mean difference is significant at the*.

V. Discussion

The absence of significant between-group differences in BMI is not entirely surprising. BMI is a relatively insensitive indicator in short-term interventions, as changes in weight and body composition tend to manifest gradually over longer durations [93–95]. Family-based interventions, even when parental involvement is present, may require extended periods—often exceeding three months—before noticeable anthropometric changes occur [96, 97].

Meta-analytical evidence supports this interpretation. A meta-analysis of 83 lifestyle intervention trials demonstrated that parent involvement is associated with a modest average reduction in BMI (−0.42 standardised units), but the effect is heterogeneous and typically observed over extended programme durations [95]. Similarly, Weber *et al.* [98] confirmed that family-based treatments yield modest but significant improvements in BMI only after more prolonged engagements.

In our context, although PIFA participants engaged more actively in physical activity (as shown in significant changes in PAL), the intervention may have lacked adequate duration or intensity to induce significant between-group differences in fat loss or mass reductions. Moreover, no dietary component or caloric monitoring was integrated into the study design, limiting the capacity to influence weight-related outcomes [99, 100]. That behavioural changes in PAL were observed yet did not translate to significant BMI differences between groups underscores the known lag between behaviour change and physiological adaptation [101, 102].

Individual variation is another plausible factor attenuating the observable between-group BMI changes. Differences in pubertal development, metabolic rate, and baseline BMI between participants may have diluted group-level differences [103, 104]. The absence of covariate adjustment for these baseline variables further limits the interpretive power of between-group BMI data.

Despite the lack of a significant between-group difference in BMI improvement, the intervention's focus on parental involvement may still be valuable. Prior research indicates that parental co-activity and support are correlated with higher adolescent physical activity levels [44, 46], and although not sufficient in this timeframe, such changes represent early steps in long-term weight management pathways [105, 106]. Over extended durations, consistent increases in PAL may translate into reductions in BMI, especially if paired with supportive modifications in dietary behaviour [107, 108].

WHR is recognised as a reliable anthropometric indicator of central adiposity and associated metabolic risk in youth [109, 110]. However, similar to BMI, WHR tends to change gradually due to the slower kinetics of adipose tissue redistribution [111, 112]. In our eight-week intervention, although adolescents engaged more actively in physical activity, evidenced by increased PAL, the duration and intensity may have been insufficient to produce a statistically significant between-group difference in central fat distribution. This pattern aligns with prior findings that short-term behavioural interventions rarely elicit such differences in WHR alone [113].

Mehdizadeh *et al.* [114] observed that several intervention studies found no significant between-group impact of parental involvement on anthropometric outcomes, including WHR, especially in short-term programmes. While some long-term, multi-component interventions (combining diet, activity, and parental engagement) have achieved significant reductions in WHR [115], our outcome underscores the limitation of isolated physical activity interventions delivered over a brief period.

Moreover, central fat reduction may be buffered by individual differences in baseline adiposity, puberty stage [116], and genetic disposition, none of which were controlled in our analysis. Without controlling for these confounders, it is possible that subtle changes occurred within subgroups but remained statistically non-significant at the group level. This variability may have masked the potential benefits of the PIFA approach.

Despite the null between-group result for WHR, it is important to note that behavioural improvements in PAL are considered early indicators of future anthropometric change [117]. Increased engagement in moderate-to-vigorous physical activity is likely to precede measurable reductions in central adiposity [118]. Thus, while our H_2 was not validated, the observed behavioural gains may lay the groundwork for later health improvements if the intervention were extended or reinforced with nutrition and family-based monitoring.

It is also plausible that WHR, as a dimensionless ratio, is less responsive to general increases in activity if overall hip circumference changes similarly, or if measurement error occurs [119]. Standardised WHR measurement protocols may not fully capture subtle fat redistribution in adolescents [120].

The observed effect aligns with meta-analytic evidence confirming that parental involvement positively influences adolescent physical activity behaviours. A multilevel meta-analysis [46] demonstrated a significant positive association between positive parental influence and children's PA levels ($r \approx 0.20$), underscoring the potency of active support in driving behavioural change. Similarly, Yao and Rhodes [47] reported a moderate pooled effect size (r = .17–.20) for the link between parental modelling and increased physical activity among adolescents. These findings suggest that incorporating parents as active co-participants in exercise programmes can enhance adolescent engagement and consistency in physical activity routines.

The design of the PIFA intervention—structured, joint parent-child exercise sessions three times per week—likely contributed to improved PAL in several ways. Parental presence may increase motivation through social reinforcement, accountability, and shared enjoyment [45]. Notably, the research by Liu et al. found that parental co-activity nearly doubled the odds of adolescents increasing their activity level during COVID-19 lockdown conditions (OR = 1.995), highlighting the influence of shared exercise on sustaining or rising PAL.

Moreover, comparison studies from Shanghai emphasised that parental encouragement, involvement, modelling, and financial support are significantly associated with higher Moderate-to-Vigorous Physical Activity (MVPA) among children and adolescents (ORs ranging from 1.2 to 2.0) [121]. In line with this, our PIFA participants, engaged in structured joint exercise, may have experienced elevated levels of instrumental and emotional support—both conducive to activity increases.

By contrast, participants in the IFA group, despite following the same exercise programme, lacked direct parental involvement, which may have contributed to lower adherence and diminished motivation. Without the structure, encouragement, and social aspects provided by parents, sustained engagement may diminish, especially in adolescent populations where intrinsic motivation is fluctuating [76].

The substantiated increase in PAL represents an important short-term behavioural achievement. While physiological markers such as BMI and WHR may take longer to change, behavioural shifts in physical activity are critical precursors to such anthropometric outcomes [122]. Longitudinal evidence suggests that sustained increases in PAL can lead to gradual improvements in body composition and health markers over time [123].

However, it is important to acknowledge that PAL was measured using self-reported questionnaires, which may inflate estimates compared to objective methods such as accelerometers [124]. Despite this limitation, the significant between-group difference strongly indicates that parental engagement in app-based exercise can meaningfully increase adolescent physical activity behaviours over an eight-week period.

VI. Conclusion

This pilot cluster-randomised controlled trial provides preliminary evidence that parental involvement via a structured fitness application (PIFA) can significantly enhance Physical Activity Levels (PAL) among overweight and obese adolescents over an 8-week period, compared to an Individual Fitness App (IFA) approach. While no significant between-group differences were observed in BMI or WHR outcomes, the marked improvement in PAL within the PIFA group underscores the potential of parent-supported digital interventions to promote positive behavioural changes in this population.

The findings suggest that parental co-engagement through app-based exercise programmes may serve as a feasible and effective strategy to increase adolescent physical activity in the short term. However, the lack of significant effects on anthropometric measures highlights the complexity of weight-related outcomes, which may require longer intervention durations, integrated dietary components, and more intensive behavioural support to translate increased activity into measurable changes in body composition.

Several limitations should be considered when interpreting these results, including the small sample size, relatively short intervention period, reliance on self-reported physical activity data, and absence of dietary monitoring. Future studies would benefit from larger and more diverse samples, longer follow-up periods, objective measures of physical activity (e.g., accelerometers), and the inclusion of dietary interventions to provide a more comprehensive assessment of family-based digital health strategies.

In summary, this study contributes to the growing literature on digital health interventions for adolescent obesity by demonstrating that parental involvement can enhance physical activity engagement. While further research is needed to optimise such interventions for sustained weight management, incorporating parents as active partners in app-based exercise programmes represents a promising approach to addressing the rising burden of youth obesity in China and similar contexts.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Tianjiao Hai designed the study, conducted the experiments, analysed the data, and wrote the manuscript; Vincent Wee Eng Kim supervised the research, provided critical revision, and validated the results; Yiqiang Mai assisted with the experiments and data collection; all authors have approved the final version.

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