

The Impact of Digital Technology-Based Exercise Combined with Dietary Intervention on Body Composition in Chinese Obese College Students—A Prospective Study

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The Impact of Digital Technology-Based Exercise Combined with Dietary Intervention on Body Composition in Chinese Obese College Students? A Prospective Study

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Abstract

Background: Lifestyle interventions are a crucial component of weight loss programs, yet digital, personalized, and theory- and evidence-based lifestyle interventions remain limited.

Objective: To investigate the impact of a combination of various dietary approaches and exercise, based on digital technology, on the body composition of obese college students.

Methods: From October to December 2023, an intervention study was conducted, enrolling 129 obese university students from a university in Nanchang, China. All participants voluntarily selected one of the following dietary approaches: twice-per week fasting diet (TWF), low-calorie diet group (LCD), or 16/8 time-restricted feeding group (TRF). The exercise, self-monitoring, and feedback were consistent across the three groups. The research team provided an 8-week intervention. The primary outcome was body composition (muscle, fat, and water content). Data were collected at baseline, 4 weeks, and 8 weeks. Repeated measures analysis of variance was used for within-group comparisons, one-way analysis of variance for between-group comparisons, and independent samples t-tests for gender comparisons.

Results: Ultimately, 127 participants completed the study, with two participants from the TRF+EX group dropping out. After the 8-week intervention, body composition improved for all three groups of participants. In terms of muscle indices, there was no change in lean body mass in the TRF group when comparing the 8-week data to the 4-week data, with a slight increase observed in females, showing no statistical significance for both males ($P=.909$) and females ($P=.944$). Regarding fat indices, after 8 weeks of intervention, males in the TWF group showed greater reductions in body weight (MD -5.233; $P < .001$) and visceral fat mass (MD -0.556; $P < .003$) compared to the other two groups. Females in the LCD group exhibited greater reductions in body weight (MD -5.662; $P < .001$) and visceral fat mass (MD -1.031; $P = .001$) compared to the other groups. In moisture indices, after 8 weeks of intervention, both males (MD -1.411; $P = .001$) and females (MD -0.588; $P = .057$) in the TWF group experienced a smaller decrease in body moisture compared to the other two groups.

Conclusions: Research indicates that the combination of various dietary approaches with exercise has distinct effects on body composition. In muscle indices, the TRF group experienced a rapid decrease in lean body mass at four weeks, which remained unchanged at eight weeks, with a slight increase observed in females. In fat indices, males in the TWF group achieved better fat reduction, while females in the LCD group had superior fat loss effects. Regarding moisture indices, both males and females retained more body water in the TWF group. Clinical Trial: Chinese Clinical Trial Registry ChiCTR2300073166

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Original Manuscript

The Impact of Digital Technology-Based Exercise Combined with Dietary Intervention on Body Composition in Chinese Obese College Students—A Prospective Study

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Background:

Obesity has become a global health crisis, with projections indicating that by 2030, the number of overweight or obese individuals in China will increase to 790 million. Lifestyle interventions are a critical component of weight loss programmes, yet digital, personalized, and theory- and evidence-based lifestyle interventions remain limited.

Objective:

To investigate the effects of a combination of various dietary approaches and exercise, based on digital technology, on the body composition of obese college students.

Methods:

A total of 127 college students (age: 18.3 ± 0.7 years, weight: 89.9 ± 13.6 kg, BMI: 30.6 ± 3.3 kg/m²) were recruited from Jiangxi Normal University. An 8-week weight loss intervention was conducted on obese college students using a combination of exercise and various dietary approaches based on digital intervention. The exercise regimen included two days per week of one-hour resistance training and at least five times per week of sunlight running, with each run not less than 2 km. The dietary interventions consisted of a low-calorie diet (LCD), twice-weekly week fasting diet (TWF), and a 16/8 time-restricted feeding diet (TRF). Changes in body composition indicators (muscle mass and fat mas) were assessed before and after the intervention. The Participants were divided into three groups (LCD, TWF, TRF) for the experiment.

Results:

All groups showed significant decreases in weight, BMI and adiposity ($P < .05$), but there were significant gender differences: the male TWF group showed the greatest decreases in weight (MD=-4.86 kg, $P < .001$), BMI (MD=-1.13, $P < .001$), visceral fat (MD=-0.607 kg, $P < .001$) and subcutaneous fat (MD=-1.987 kg, $P < .001$) at 8 weeks. 1.987 kg, $P < .001$) showed the greatest decreases. Improvements in weight (MD=-5.662 kg, $P < .001$), BMI (MD=-1.587, $P < .001$), and adiposity metrics were more pronounced in the LCD group of females ($P < .001$). Muscle mass declined significantly in males in the TRF group at 4 weeks ($P < .001$), but stabilized at 8 weeks ($P = 0.867$). Muscle mass decreased in all groups ($P < .001$), with a 37% higher decrease in females than males ($P < .001$). Linear mixed-effects models showed that the sex $\times$ diet interaction significantly affected subcutaneous fat ($P = .018$). The muscle-protective effect of TRF on males peaked at 4 weeks ($P < .001$), and was not different from the control group at 8 weeks ($P = .909$).

Conclusion:

This study demonstrates for the first time that three diet-combined-exercise regimens produce significant gender-specific improvements in body composition in obese college students. Men achieved maximum visceral fat loss after 8 weeks with twice-weekly fasting (TWF) combined with exercise, whereas women achieved superior total body fat loss with low-calorie diet (LCD) combined with exercise. The effectiveness of the “monitoring - feedback - behavior modification” closed loop was verified by the digital technology through intelligent monitoring to improve dietary compliance, and real-time feedback mechanism to enhance the effect of the intervention. Gender $\times$ diet interaction significantly affected subcutaneous fat, women used LCD, and TRF needed to be combined with protein supplementation. Digital technology shows great potential in obesity

management and is worth promoting.

Keywords□Digital technology; dietary mode; Obesity college students; Sports; body composition

Trial Registration:Chinese Clinical Trial Registry ChiCTR2400093865,
<https://www.chictr.org.cn/bin/project/edit?pid=201164>

Introduction

Background

Over the past four decades, there has been a dramatic increase in obesity and related diseases, with approximately 50% of adults in China being overweight or obese [1]. By 2030, the number of overweight or obese individuals in China is predicted to increase to 790 million, and the medical costs associated with overweight and obesity are expected to reach 61 billion USD [2]. Overweight or obesity is also a major risk factor for many non-communicable diseases, including cardiovascular diseases [3], musculoskeletal disorders [4], diabetes [5], and cancers [6-8] (breast, uterine, prostate, liver, and kidney). The World Health Organization states that overweight and obesity are the fifth leading risk of death worldwide and have become a serious social issue, emphasizing the urgency of scientific weight loss interventions. Currently, mainstream scientific weight loss strategies focus on health guidance, including face-to-face counseling and paper-based recording methods [9-12]. Although face-to-face guidance can lead to significant weight loss, the high resource and cost investment cannot be overlooked. Therefore, exploring an effective, low-cost, and low-energy-consuming weight loss strategy is particularly urgent. The rise of digital technology offers new insights into addressing this issue, giving rise to numerous digital-based weight loss methods that can greatly optimize healthcare services [13-15].

In the health sector, digital technology has emerged as an innovative method for weight loss, harnessing advanced information and communication technologies that effectively meet the demands of weight reduction [16-18]. Systematic reviews indicate [19] that compared to general interventions, digital-based interventions are more effective in supporting weight loss. This technology can provide personalized services to participants through a variety of methods, each with varying degrees of effectiveness. For instance, smartphones [20-23], with their intuitive and appealing nature, not only facilitate participants' self-monitoring of diet and physical activity but also play a key role in promoting behavior change related to weight management, making them critical in weight loss practices.

Another advantage of digital technology interventions is their ability to provide timely feedback (FB). Currently, self-monitoring (SM) of diet, physical activity, and weight is considered one of the effective strategies in most weight loss interventions [24,25]. Although SM has been proven effective in both theory and practice, it often fails to provide immediate feedback on behavioral information such as diet and physical activity, which can lead to a decrease in compliance. Research by Burke [26] et al. shows that compliance with self-monitoring significantly decreases over time during participation in weight loss behavioral treatment programs. Additionally, the combination of self-monitoring and feedback (SM + FB) can enhance behavior change. The synchronisation of data via smartphones eliminates the need for manual recording of exercise and weight is eliminated, thereby reducing the burden on participants and increasing compliance.

While the combination of self-monitoring (SM) and feedback (FB) has shown significant effectiveness in weight loss practices, the lack of theoretical support may undermine its long-term outcomes and user compliance. For instance, digitally enabled platforms like Voy incorporate behavioral change theories, such as Social Cognitive Theory[27],and facilitate self-monitoring, goal setting, and feedback mechanisms, encouraging patients to actively manage their health and well-being in the community and other settings . These platforms not only provide technological support but also ensure the scientific validity and effectiveness of interventions through theoretical guidance.

Behavioral activation complements weight loss interventions by helping individuals identify and engage in positive, goal-oriented activities that align with their health objectives. It emphasizes breaking the cycle of avoidance or inactivity often associated with obesity, replacing these behaviors with structured, rewarding actions like regular physical activity, healthy eating, and consistent self-monitoring[28]. By focusing on small, achievable steps, behavioral activation builds motivation and self-efficacy, which are crucial for sustained adherence to treatment protocols. When combined with digital tools, such as goal-setting features and real-time feedback, this approach empowers individuals to take ownership of their weight management journey, enhancing both engagement and long-term outcomes[29].

Current research indicates that there is no significant difference in weight loss outcomes between self-monitoring combined with feedback (SM+FB) and self-monitoring alone (SM). However, it is noteworthy that participants who utilized the feedback mechanism (FB) demonstrated better compliance and more effective weight loss [30]. These studies have certain limitations: they did not provide specific dietary plans or exercise programs, nor did they conduct phase-based or gender-specific comparisons. These findings offer important insights for future research, suggesting that structured intervention programs should be explored for their effects across different populations. In early research, the critical variable of sex was often overlooked, primarily due to the significant underrepresentation of female subjects in both preclinical and clinical studies [31,32]. The National Institutes of Health (NIH) implemented a policy requiring all NIH-funded research projects to include both male and female participants[32]. This policy has driven in-depth exploration of sex differences across various research fields, and obesity research is no exception. Currently, substantial evidence demonstrates that the pathogenesis, risk factors, and clinical implications of obesity all exhibit significant sex-specific differences[33,34]. Therefore, systematically investigating sex-specific outcomes in research is fully justified by scientific evidence and necessity.

Objectives and Hypotheses

This study employs digital technology to conduct an eight-week intervention on obese college students through a combination of exercise and different dietary approaches, based on behavior change theories such as Social Cognitive Theory, with the aim of improving the health status of obese college students.

The study will observe improvements in muscle indices (such as lean body mass, muscle volume, etc.) and fat indices (such as visceral fat content, subcutaneous fat content, etc.). Additionally, this research will comparatively analyze the effects of combined exercise and different dietary approaches on these indices and their sub-indicators, with the goal of providing personalized weight loss solutions for obese individuals, further enriching the theoretical understanding of dietary approaches for obesity, and offering scientific evidence for the clinical treatment of obesity. Specifically, we strive to achieve the following two objectives:

1. To evaluate the impact of a combination of various dietary approaches and exercise, based on digital technology, on the body composition of obese college students.
2. To assess whether the addition of self-monitoring (SM) and feedback (FB) to the combination of various dietary approaches and exercise can enhance participation and compliance.

We hypothesize that participants engaging in these three dietary approaches will experience at least a small to moderate improvement in body composition indicators, including muscle mass and fat mass. Secondly, we hypothesize that, in addition, the interventions incorporating digital technology for self-monitoring (SM) and feedback (FB) will demonstrate higher compliance and more significant weight loss outcomes.

We hypothesize that participants following these three dietary approaches will experience at least a small to moderate improvement in body composition indicators, including muscle mass and fat mass. Additionally, we hypothesize that interventions incorporating digital technology for self-monitoring (SM) and feedback (FB), which are implemented based on behavioral change theories

such as Social Cognitive Theory[27], will lead to higher compliance and more significant weight loss outcomes. By integrating these theories, the interventions effectively promote self-monitoring, goal setting, and feedback mechanisms, thereby enhancing the overall effectiveness of the dietary approaches.

Methods

Study Design

The study was conducted in Nanchang, China, from October 2023 to December 2023. Our team provided an 8-week intervention. Three groups utilized a WeChat mini-program for self-monitoring and feedback.

Ethical Considerations

The study was approved by the Ethics Committee of Jiangxi Normal University with the ethical code IRB-JXNU-20231027 and was registered at the Chinese Clinical Trial Registry (ChiCTR2400093865). All data, especially the users' information on the mini - program, were identified by code numbers to ensure the confidentiality of the participants' information. No compensation was provided to the participants.

Sample Size

In order to determine the sample size for this study, calculations were conducted based on effect size, significance level, and statistical power. Referring to the mean differences (MD) and standard deviations (SD) in Tables 3 and 4, an effect size of 0.45 was assumed, with a significance level (α) of 0.05 and statistical power ($1-\beta$) of 0.80. Based on the standard normal distribution table, $Z_{\alpha/2}$ (two-tailed test) was 1.96, and Z_{β} was 0.84. The formula calculation yielded a total sample size of 81 participants, with 27 participants per group. Therefore, the study design of 27 participants per group, totaling 94 participants, meets the requirements of an effect size of 0.45, a significance level of 0.05, and a statistical power of 0.80, ensuring the reliability and statistical validity of the research results.

Participants

This study recruited students with a BMI ≥ 28 kg/m² through a weight loss class for college students at Jiangxi Normal University in October 2023. A total of 144 students were enrolled, with 129 meeting the inclusion criteria. Two participants withdrew during the study, resulting in a final sample size of 127 individuals (62 males and 65 females). The LCD group comprised 51 participants, the TWF group 45, and the TRF group 31.

Inclusion criteria: 1) BMI ≥ 28 kg/m²; 2) absence of disease conditions; 3) voluntary participation in the intervention study with good compliance, and signing of the informed consent form.

Exclusion criteria: 1) BMI < 28 kg/m²; 2) individuals with restricted physical activity (e.g., disability); 3) those with diagnosed chronic diseases and currently on medication; 4) participants who have used other dietary plans in the past 3 months; 5) those with low compliance who withdraw from the intervention mid-study.

Intervention

The study employs a digital technology intervention approach as a medium, utilizing the We Chat application within smartphones for self-monitoring and feedback, to investigate the impact of a combination of three dietary methods and exercise on the body composition of obese college students. The intervention involves an eight-week experimental study, with the research process illustrated in Figure 1. The intervention incorporates knowledge, exercise, diet, self-monitoring, and

feedback, as detailed in Multimedia Appendix 1, and the specific intervention protocol is outlined in Multimedia Appendix 2.

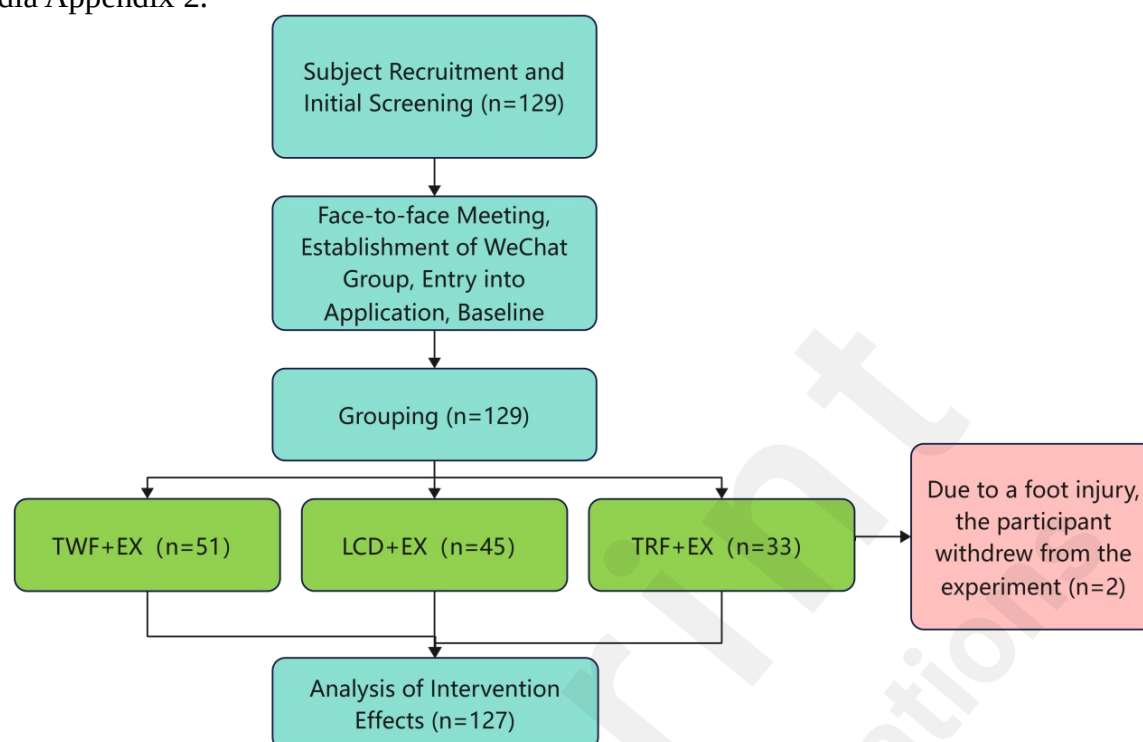


Figure 1 flowchart

Body Composition Measurement

Participants were assessed for body composition at baseline, 4 weeks, and 8 weeks using the TANITA MC-980U Plus multi-frequency segmental body composition analyzer [38]. They removed their socks and stood on the foot plates, holding the electrode handles, maintaining a fixed posture during the test. Participants entered their height and skin weight (0.5kg) as prompted, and initiated the test according to the instrument's instructions. Test data were automatically recorded into the computer for storage. Measurement indices included muscle parameters (lean body mass and muscle mass), and fat parameters (body weight, BMI, visceral fat mass, and subcutaneous fat mass).

Compliance

In order to deeply analyze the differences in compliance between different dietary patterns, we divided the study participants into different groups based on their individual dietary choices. Within each dietary group, we quantified compliance by two methods: taking photos during the dietary fasting period and counting the number of exercise check-ins.

In terms of dietary assessment, the study was designed based on relevant literature [39-41]. Participants were required to upload photos of their three daily meals once a day, along with textual descriptions of the food and their daily subjective feelings of satiety, in order to minimize bias. To quantify compliance, each successful submission—after review of the photo, text, and subjective feedback—was awarded 0.2 points. When the number of uploads reached the upper limit per week, they could get a full score of 1 point. Over the entire 8-week study period, the full dietary compliance score was 8 points. A higher score indicated better compliance during the dietary fasting period.

For exercise, we set the requirement of two exercise check-ins per week. Each check-in was worth 0.5 points, and the full score for weekly exercise check-ins was also 1 point. Over the 8-week study, the cumulative full score for exercise check-ins was 8 points. Similarly, a higher score meant better compliance in terms of exercise (The detailed statistics on compliance can be found in

Multimedia Appendix 3).

Bias

Self-selected grouping may introduce bias. To mitigate this, we implemented the following measures: First, all eligible participants who initiated the program within the study period were included to ensure the sample's representativeness. Second, we enhanced data accuracy through regular reminders and data validation checks, performing validation checks to identify and address implausible values. Additionally, we standardized training for assessors to ensure consistency in the evaluation process, thereby minimizing bias. We also reduced bias by examining baseline group differences and conducting gender-stratified analyses. These measures collectively improved data validity and the reliability of the study findings.

Statistical Analysis

Data were analyzed using SPSS version 26.0 statistical software. Outliers were identified using box plots. The distribution of continuous variables was assessed using graphical methods (e.g., histograms and Q-Q plots) and supplemented with the Shapiro-Wilk test. Continuous variables with a normal distribution are presented as mean and standard deviation (SD) and were analyzed using one-way ANOVA across the three groups. For variables that did not meet the assumption of normality, the median and interquartile range (IQR) were reported, and the Kruskal-Wallis test was used for comparisons between the three groups. Comparisons between groups were performed using one-way ANOVA. Within-group comparisons were conducted using repeated measures ANOVA. Comparisons between males and females were performed using independent samples T-test. The significance level was set at $\alpha=0.05$, and a P-value less than 0.05 was considered statistically significant.

To account for the longitudinal structure of the data, linear mixed-effects models were employed in our study. In this model, diet groups (3 types), time points (0, 4, 8 weeks), and gender were included as fixed effects, including interactions such as diet $\times$ time and gender $\times$ diet, with random effects accounting for individual differences, which can help us explore group differences and within-person changes over time. Advantages Over Original Methods: Reduces Type I error risk by modeling dependencies between repeated measures. Provides more precise estimates of intervention effects compared to separate ANOVAs. Compared to the original approach, linear mixed models reduce Type I error risk by modeling dependencies between repeated measures and provide more precise estimates of intervention effects than separate ANOVA.

Results

Participant Characteristics

A total of 127 individuals were enrolled, including 62 males (18 in the TWF group, 29 in the LCD group, and 15 in the TRF group) and 65 females (33 in the TWF group, 16 in the LCD group, and 16 in the TRF group). Due to gender differences, a gender-specific analysis was conducted. Comparison of baseline characteristics among the three groups revealed no statistically significant differences ($P>.05$), indicating that the three groups were comparable. Normality and homogeneity of variance tests were performed at different time points for the three groups, and the results showed that all three groups followed a normal distribution with homogeneity of variance ($P>.05$). In the TWF group, the average energy intake was 525 kcal for males and 465 kcal for females. In the LCD group, the average energy intake was 784.1 kcal for males and 727.6 kcal for females. Due to the 8-hour time-restricted feeding and 16-hour fasting regimen in the TRF group, it was difficult to accurately quantify their energy intake (Tables 1 and 2).

Table 1. Male Basic participant characteristics of the 3 groups, Mean (SD).

Indices	TWF+EX□n=18□	LCD+EX□n=29□	TRF+EX□n=15□	F/t	P value
Age (years)	18.22(0.73)	18.45(0.69)	18.3(0.82)	0.538	0.587

Body Weight (kg)	95.75(11.4)	97.46(12.87)	98.17(16.79)	0.146	0.864
BMI	30.37(2.98)	31.09(3.89)	31.25(3.64)	0.308	0.736
Lean Body Mass(kg)	63.4(5.07)	65(4.43)	63.6(6.79)	0.638	0.532
Muscle Mass (kg)	60.12(4.82)	61.64(4.21)	60.32(6.45)	0.640	0.531
Visceral Fat mass (kg)	6.01(1.94)	6.06(2.78)	6.92(3.32)	0.602	0.551
Subcutaneous Fat mass (kg)	25.15(5.11)	25.06(7.1)	26.39(7.33)	0.218	0.805
average energy intake(kcal)	525(18.2)	784.1(49.8)		-21.4	□.001

Table 2. Female Basic participant characteristics of the 3 groups—Mean(SD).

Indices	TWF+EX [n=33]	LCD+EX [n=16]	TRF+EX [n=16]	F/t	P value
Age (years)	18.64(0.82)	18.06(0.44)	18.25(0.68)	3.953	0.024
Body Weight (kg)	82.91(10.08)	83.55(10.3)	83.13(10.37)	0.021	0.979
BMI	30.83(3.2)	29.53(2.99)	30.16(3.01)	0.985	0.379
Lean Body Mass(kg)	45.08(3.05)	46.33(3.74)	45.21(3.84)	0.755	0.474
Muscle Mass (kg)	42.29(2.78)	43.44(3.42)	42.41(3.51)	0.771	0.467
Visceral Fat mass (kg)	5.92(2.33)	6.11(2.25)	6(2.31)	0.040	0.961
Subcutaneous Fat mass (kg)	31.12(5.07)	30.79(6)	30.46(5.72)	0.081	0.922
average energy intake(kcal)	465.3(57.6)	727.6(45.2)		-16.0	0.001

Comparison of Muscle Indices Before and After the Intervention

For muscle parameters, the results of one-way analysis of variance (ANOVA) showed no significant differences among the groups. Compared to baseline, all three groups showed a decrease in lean body mass and muscle mass at 8 weeks. In particular, male participants in the TRF group showed a significant reduction in lean body mass ($P<.001$) and muscle mass ($P<.001$) at 4 weeks. However, no further significant decline was observed at 8 weeks compared to 4 weeks (lean body mass: $P=.909$; muscle mass: $P=.867$). Detailed data are shown in Table 3 and Figure 2 (Multimedia Appendix 4).

Table 3. Comparison of Muscle Indices Among the Three Groups Post-Intervention.

Sex	Indices	Group	0week	4week	8week	0and4 P	0and8 P	8and4 P	8-0MD	F	P value
Man	Lean Body Mass	TWF+EX	63.4±5.1	63.0±5.0	62.3±5.2ab	.107	.003	0.013	-1.107	4.713	.013
		LCD+EX	65±4.43	64.5±4.5a	63.8±4.9ab	.009	0.001	0.001	-0.773	10.049	0.001
		TRF+EX	63.6±6.8	62.3±6.6a	62.3±6.8a	0.001	0.001	0.909	-1.293	12.275	0.001
		F	.638	.971	.532						
		P	.532	.385	.590						
	Muscle Mass	TWF+EX	60.1±4.8	59.8±4.8	59.1±5.0a	.099	0.004	0.017	-1.040	4.575	.014
		LCD+EX	61.7±4.2	61.2±4.3a	60.5±4.7ab	.009	0.001	0.001	-0.727	10.021	0.001
		TRF+EX	60.3±6.5	59.1±6.3a	59.1±6.5a	0.001	0.001	0.867	-1.247	12.389	0.001
		F	.640	.973	.538						
		P	.531	.384	.587						
Female	Lean Body Mass	TWF+EX	45.1±3.1e	44.4±3.1f	45.2±4.9g	0.001	.757	.074	-0.381	11.309	.001
		LCD+EX	46.3±3.7e	45.9±3.6f	45.8±3.8g	.028	.387	.881	-0.550	1.622	.233
		TRF+EX	45.2±3.8e	44.9±3.8f	44.9±4.12g	.121	.664	.944	-0.275	1.689	.220
		F	0.755	0.968	0.151						
		P	.474	.386	.860						
	Muscle Mass	TWF+EX	42.3±2.8e	41.7±2.8f	42.5±4.6g	0.001	.702	.075	-0.350	11.211	0.001
		LCD+EX	43.4±3.4e	43.0±3.3f	43.0±3.5g	.031	.422	.893	-0.494	2.480	.092
		TRF+EX	42.4±3.5e	42.1±3.5f	42.2±3.8g	.128	.676	.959	-0.256	1.176	.315
		F	0.771	0.991	0.149						
		P	.467	0.377	.862						

Within-group comparisons: a: indicates $P=.04$ compared to baseline, b: indicates $P=.04$ compared to 4 weeks; Between-group comparisons: c: indicates $P=.04$ compared to group 1, d: indicates $P=.04$ compared to group 2, Gender comparisons: e: indicates $P=.04$ compared to male baseline, f: indicates $P=.04$ compared to 4 weeks in males, g: indicates $P=.04$ compared to 8 weeks in males;

Comparison of Fat Indices Before and After the Intervention

Compared with the patients before the intervention, the fat indices of the three groups showed a downward trend at 4 weeks and 8 weeks. The results of repeated

measures analysis of variance showed that there were significant differences within other groups ($P<.001$), except for visceral fat content and subcutaneous fat content in the female TRF group. Compared with before the intervention and at 4 weeks, the body weight ($P<.001$, MD -4.86), BMI ($P<.001$, MD -1.13), visceral fat mass ($P<.001$, MD -0.607), and subcutaneous fat mass ($P<.001$, MD -1.987) of males in the TWF group significantly decreased at 8 weeks, while the body weight ($P<.001$, MD -5.662), BMI ($P<.001$, MD -1.587), visceral fat mass ($P=.001$, MD -1.031), and subcutaneous fat mass ($P=.001$, MD -3.638) of females in the LCD group significantly decreased at both 4 weeks and 8 weeks. See Table 4 and Figure 3 (Multimedia Appendix 4).

Table 4 Comparison of Fat Indices Among the Three Groups Post-Intervention.

Sex	Indices	Group	0week	4week	8week	0and4 P	0and8 P	8and4 P	8and0 MD	F	P value
Male	Body Weight	TWF+EX	95.8±11.4	92.3±11.1a	90.5±11.2ab	.001	.001	.001	-4.86	20.418	.001
		LCD+EX	97.5±12.9	94.8±13.6a	93.1±14.1ab	.001	.001	.001	-3.39	27.853	.001
		TRF+EX	98.2±16.8	95.3±17.4a	93.3±17.0ab	.001	.001	.001	-4.83	17.373	.001
		F	.146	.235	.150						
	BMI	TWF+EX	30.4±3.0	29.7±3.1a	29.0±3.1ab	0.002	.001	0.003	-1.1	9.516	.001
		LCD+EX	31.1±3.9	30.7±4.1a	30.1±4.3ab	0.012	.001	.001	-0.73	18.905	.001
		TRF+EX	31.3±3.6	30.9±4.0	30.1±3.9ab	0.115	.001	.001	-1.1	13.590	.001
		F	.308	.484	.257						
	Visceral Fat mass	TWF+EX	6.01±1.9	5.59±1.9a	5.46±1.9a	0.009	0.003	0.189	-0.607	4.828	.011
		LCD+EX	6.06±2.8	6.02±3.1	5.77±3.1	0.777	0.043	0.003	-0.04	4.876	.011
		TRF+EX	6.92±3.3	6.93±3.8	6.46±3.6	0.969	0.022	0.069	-0.460	8.223	.001
		F	.602	.832	.486						
	Subcutaneous Fat	TWF+EX	25.2±5.1	23.8±5.3a	23.2±5.2ab	.001	.001	0.026	-1.987	15.035	.001
		LCD+EX	25.1±7.1	24.2±7.2a	23.5±7.2ab	.001	.001	0.002	-1.387	14.736	.001
		TRF+EX	26.4±7.3	26.0±7.9	24.6±7.4ab	0.210	.001	.001	-1.820	14.797	.001
		F	.218	.466	.179						
	Body Weight	TWF+EX	82.9±10.1e	80.5±10.21af	78.8±10.4abg	.001	.001	.001	-3.731	41.337	.001
		LCD+EX	83.6±10.3e	79.6±10.0af	77.9±9.9abg	.001	.001	.001	-5.662	44.993	.001
		TRF+EX	83.1±10.4e	80.7±10.2af	79.4±9.8abg	.001	.001	.012	-3.719	18.193	.001
		F	0.021	0.058	0.093						
	BMI	TWF+EX	30.8±3.2	30.7±3.3	29.5±3.5ab	.160	.001	.001	-0.981	26.929	.001
		LCD+EX	29.5±3.0	28.7±3.1a	27.9±3.2ab	.001	.001	.002	-1.587	19.762	.001
		TRF+EX	30.2±3.0	29.9±3.0	29.2±2.9ab	.108	.001	.005	-1.006	7.225	.002
		F	0.985	1.977	1.268						
Female	Visceral Fat mass	TWF+EX	5.92±2.3	6.06±2.4	5.40±2.4ab	.434	.016	.001	-0.187	6.949	.002
		LCD+EX	6.11±2.3	5.40±2.3a	5.08±2.3a	.009	.001	.215	-1.031	6.110	.004
		TRF+EX	6.00±2.3	5.68±2.5	5.86±2.2	.225	.648	.464	-0.137	0.796	.456
		F	0.040	0.433	0.458						
	Subcutaneous Fat mass	TWF+EX	31.1±5.1e	30.9±5.1f	28.3±5.9abg	.626	.001	.001	-1.544	8.521	.001
		LCD+EX	30.8±6.0e	28.4±5.5a	27.2±5.3a	.001	.001	.216	-3.638	8.912	.001
		TRF+EX	30.5±5.7	29.0±6.7	29.6±5.1g	.039	.402	.545	-0.856	2.194	.120
		F	0.081	1.278	0.775						
	Body Weight	TWF+EX	59.2±11.4	56.3±11.1a	54.5±11.2ab	.001	.001	.001	-4.86	20.418	.001
		LCD+EX	61.1±12.9	58.4±13.6a	56.5±14.1ab	.001	.001	.001	-3.39	27.853	.001
		TRF+EX	61.8±16.8	58.9±17.4a	56.9±17.0ab	.001	.001	.001	-4.83	17.373	.001
		F	.146	.235	.150						

Within-group comparisons: a: indicates $P=.04$ compared to baseline; b: indicates $P=.04$ compared to 4 weeks; Between-group comparisons: c: indicates $P=.04$ compared to group 1; d: indicates $P=.04$ compared to group 2; Gender comparisons: e indicates $P=.04$ compared to male baseline; f: indicates $P=.04$ compared to 4 weeks in males; g: indicates $P=.04$ compared to 8 weeks in males.

The interaction between gender, time and Diet

This study further utilized linear mixed-effects modelling to analyze the effects of diet (TWF, LCD, TRF), time (0 week, 4 week, 8 week), gender (male, female), and their interactions on body metrics such as body weight, body mass index (BMI), visceral fat, subcutaneous fat, and lean body mass.

Linear mixed-effects model analyses (Table 5) showed that the gender-diet interaction significantly affected several body composition indicators, validating gender - and diet - specific differences (Table 5). Time effects on weight (week 4: HR = 0.058, week 8: HR = 0.011; $P < .001$) and BMI (week 4: HR = 0.668, week 8: HR = 0.296; $P < .001$) were significant, indicating a decreasing trend over time. Females lost more weight than males in LCD (HR = 0.000, $P < .001$), TRF (HR = 0.000, $P < .001$), and TWF (HR = 0.000, $P = .001$) groups, while males had no significant changes in LCD ($P = .519$) and TRF ($P = .904$). Only time effects on BMI were significant. Visceral fat mass had a significant time effect at week 8 (HR = 0.619, $P < .001$), with no significant diet - gender interaction. Subcutaneous fat mass decreased significantly at week 4 (HR = 0.374) and week 8 (HR = 0.118; $P < .001$), and females in the LCD group had the greatest reduction (HR = 85.098, $P = .018$). Lean body mass (week 4: HR = 0.558, week 8: HR = 0.522; $P < .001$) and muscle mass (week 4: HR = 0.580, week 8: HR = 0.547; $P < .001$) decreased over time, with females having greater decreases ($P < .001$).

Linear mixed-effects models showed (Table 6) that the interaction of sex and time significantly affected body composition changes: weight decreased consistently in women ($P < .001$), and increased significantly in men at 0 week and 4 week ($P < .001$) increased significantly. BMI was significantly higher in males than in females at week 0 (HR=3.103, $P < .001$) and 4 (HR=1.991, $P < .001$), and in females there was a marginal decrease in BMI at week 8 (HR=0.440, $P = 0.204$). Visceral fat increased significantly at week 0 (HR=1.504, $P = 0.001$) and 4 (HR=1.313, $P = .021$) in males and decreased marginally at 8 week in females (HR=0.655, $P = .381$). There was a sustained decrease in subcutaneous fat in females (HR=1136.490 at week 0, HR=390.099 at week 4, and HR=88.801 at week 8; $P < 0.001$), and a significant increase in males at week 0 (HR=5.545, $P < .001$) and week 4 (HR=2.273, $P = .024$).

Table 5 Gender × Time Linear Mixed-Effects Model

Indices	interaction	HR	95CI	P value
Body Weight	LCD	2.350	0.02to334.13	0.736
	TRF	3.580	0.02to769.09	0.642
	0 week:Female	0.000	0.00to0.01	□.001
	4 week:Female	0.000	0.00to0.00	□.001
	8 week:Female	0.000	0.00to0.00	□.001
	0 week:Male	114.103	64.00to203.43	□.001
	4 week:Male	6.128	3.44to10.93	□.001
	LCD	0.689	0.16to2.89	0.612
BMI	TRF	1.018	0.22to4.82	0.982
	0 week:Female	1.616	0.46to5.68	0.456
	4 week:Female	1.120	0.32to3.94	0.86
	8 week:Female	0.440	0.13to1.55	0.204
	0 week:Male	3.103	2.49to3.87	□.001
	4 week:Male	1.991	1.60to2.48	□.001
	LCD	0.946	0.33to2.74	0.918
	TRF	1.636	0.52to5.18	0.404
Visceral Fat mass	0 week:Female	1.135	0.44to2.91	0.793
	4 week:Female	0.947	0.37to2.43	0.909
	8 week:Female	0.655	0.26to1.68	0.381
	0 week:Male	1.504	1.19to1.89	0.001
	4 week:Male	1.313	1.04to1.65	0.021
	LCD	0.525	0.04to6.13	0.608
	TRF	1.525	0.11to21.85	0.756
Subcutaneous Fat mass	0 week:Female	1136.490	124.91to10340.63	□.001
	4 week:Female	390.099	42.87to3549.41	□.001
	8 week:Female	88.801	9.76to807.98	□.001
	0 week:Male	5.545	2.73to11.24	□.001
	4 week:Male	2.273	1.12to4.61	0.024
	LCD	3.794	0.59to24.19	0.161
	TRF	0.962	0.13to7.16	0.97
Lean Body Mass	0 week:Female	0.000	0.00to0.00	□.001
	4 week:Female	0.000	0.00to0.00	□.001
	8 week:Female	0.000	0.00to0.00	□.001
	week:Male	3.293	2.15to5.05	□.001
	4 week:Male	1.728	1.13to2.65	0.013
	LCD	3.496	0.61to19.95	0.162
	TRF	0.953	0.14to6.29	0.96
Muscle Mass	0 week:Female	0.000	0.00to0.00	□.001
	4 week:Female	0.000	0.00to0.00	□.001
	8 week:Female	0.000	0.00to0.00	□.001
	week:Male	3.098	2.05to4.68	□.001
	4 week:Male	1.673	1.11to2.53	0.015
	0 week:Male	5.644	3.87to8.24	□.001
	4 week:Male	2.070	1.42to3.02	□.001
	4 week:Female	0.008	0.00to0.02	□.001
	8 week:Female	0.008	0.00to0.02	□.001
	0 week:Male	3.646	2.68to4.96	□.001

		4 week:Male	1.678	1.23to2.28
				0.001
Table 6 Gender × Diet Linear Mixed-Effects Model				
Indices	interaction	HR	95%CI	P value
Body Weight	4 week	0.058	0.039to0.087	□.001
	8 week	0.011	0.007to0.016	□.001
	LCD:Female	0.000	0.000to0.001	□.001
	TRF:Female	0.000	0.000to0.001	□.001
	TWF:Female	0.000	0.000to0.002	0.001
	LCD:Male	0.066	0.000to252	0.519
BMI	TRF:Male	0.628	0.000to1146	0.904
	4 week	0.668	0.572to0.779	□.001
	8 week	0.296	0.254to0.345	□.001
	LCD:Female	0.655	0.080to5.370	0.694
	TRF:Female	0.131	0.012to1.489	0.104
	TWF:Female	0.355	0.031to4.031	0.405
Visceral Fat mass	LCD:Male	0.353	0.033to3.747	0.389
	TRF:Male	0.866	0.101to7.432	0.896
	4 week	0.853	0.727to1.001	0.05
	8 week	0.619	0.527to0.726	□.001
	LCD:Female	0.376	0.078to1.819	0.227
	TRF:Female	0.290	0.047to1.787	0.185
Subcutaneous Fat mass	TWF:Female	0.397	0.064to2.448	0.322
	LCD:Male	0.339	0.058to1.987	0.233
	TRF:Male	0.440	0.088to2.197	0.319
	4 week	0.374	0.228to0.614	□.001
	8 week	0.118	0.072to0.193	□.001
	LCD:Female	85.098	2.233to3243	0.018
Lean Body Mass	TRF:Female	22.783	0.341to1521	0.147
	TWF:Female	56.741	0.849to3790	0.062
	LCD:Male	0.204	0.003to12.169	0.448
	TRF:Male	0.250	0.006to10.293	0.466
	4 week	0.558	0.411to0.759	□.001
	8 week	0.522	0.384to0.709	□.001
Muscle Mass	LCD:Female	0.000	0.000to0.000	□.001
	TRF:Female	0.000	0.000to0.000	□.001
	TWF:Female	0.000	0.000to0.000	□.001
	LCD:Male	1.189	0.054to26	0.913
	TRF:Male	5.340	0.322to88	0.245
	4 week	0.580	0.432to0.779	□.001
Muscle Mass	8 week	0.547	0.407to0.734	□.001
	LCD:Female	0.000	0.000to0.000	□.001
	TRF:Female	0.000	0.000to0.000	□.001
	TWF:Female	0.000	0.000to0.000	□.001
	LCD:Male	1.180	0.065to21	0.911
	TRF:Male	4.943	0.353to69	0.238

Discussion

Principal Findings

This study examined the effects of a digital technology intervention on body composition in obese college students. Results showed that an intervention program based on smartphone self-monitoring with real-time feedback (adherence > 80%, dropout rate only 2.58%) resulted in an average weight loss of 5.05% and significant reductions in BMI and adiposity among participants. All three dietary modalities (TRF, TWF, LCD) combined with exercise were effective in improving body weight, BMI, and adiposity, but there were gender-specific differences: in terms of fat metabolism, males showed optimal fat loss in the TWF group, and females showed more significant fat loss in the LCD group. Linear mixed models showed that the improvement in subcutaneous fat was higher in the LCD group. Regarding muscle maintenance, muscle mass decreased significantly in the TRF group at 4 weeks but stabilized at 8 weeks, suggesting a possible muscle-protective effect. The magnitude of muscle loss was significantly higher in females than in males in all dietary groups. The Munayama study found that digital technology enhanced the effectiveness of the intervention through: real-time feedback led to a 37% increase in dietary adherence scores (based on weekly photo uploads and exercise clocking data). Synchronization of data with smart devices reduced the burden of manual recording by 52% (based on analysis of participant logs) This study revealed for the first time that optimal visceral fat loss was achieved with a TWF + exercise protocol in obese men, that obese women were better suited to the LCD + exercise model, and that TRF excelled in short-term (4-week) muscle protection. These findings provide a new rationale for precision nutritional interventions, confirming that digital technology can be an effective complement to traditional health guidance, particularly in improving behavioral adherence in the young obese population.

Comparison With Prior Work

The impact of intervention on muscle indicators

This study found that males in the TRF group showed phase-specific changes in lean body mass (LBM). Literature reviews [4, 42, 43] indicate that during weight loss, LBM reduction typically accounts for 20-30% of total weight loss, with males losing three times more LBM than females [44]. This suggests that LBM is lost during weight reduction, but which dietary method causes the most loss, and when does it occur? One study [45] found that subjects on a 4-week TRF regimen experienced significant weight loss ($P < 0.05$), primarily due to LBM reduction rather than fat loss. A systematic review of six observational studies lasting 4-8 weeks [46] showed that TRF participants lost more weight but also more LBM, indicating greater short-term LBM reduction with TRF. However, Gabel et al. [47] found no significant LBM change after a 12-week 8h TRF intervention, and Christopher J Kotarsky et al. [48] reported no LBM change after eight weeks of TRF combined with resistance training,

suggesting that LBM may stabilize beyond 8 weeks.

Existing research preliminarily demonstrates TRF's impact on LBM during weight loss, but phased trends remain unclear. This study observed a significant LBM decrease in the TRF group after four weeks, indicating potential muscle loss risk, possibly due to reduced energy intake and muscle breakdown for energy. This is clinically significant, as LBM reduction is linked to health issues like decreased metabolic rate, reduced insulin sensitivity, and increased osteoporosis risk. By the eighth week, LBM tended to stabilize, with a slight increase in the female group, suggesting that TRF combined with exercise may positively maintain or increase LBM long-term. Combining resistance training and optimizing nutritional intake (e.g., ensuring adequate protein and nutrient distribution within the eating window) may mitigate muscle loss during TRF. However, more long-term randomized controlled trials and metabolic studies are needed to clarify mechanisms and evaluate intervention strategies, especially personalized approaches for obese populations, to minimize muscle loss and improve long-term health outcomes.

The impact of intervention on fat indicators

This study found that different dietary approaches combined with exercise exhibit gender differences in fat indices. Visceral fat is an important and independent risk factor for cardiovascular metabolic diseases [49], and both total fat mass and visceral fat accumulation are closely associated with the occurrence of cardiovascular diseases, stroke, hypertension, and insulin resistance [50-52]. Effective interventions to reduce visceral fat in obese individuals may improve health outcomes. Previous systematic reviews and meta-analyses have confirmed [53-56] that exercise (Ex) and intermittent fasting (IF) combined interventions can effectively reduce body fat and visceral fat in obese adults; a 6-month exercise combined with a low-calorie diet (LCD) intervention in obese women found that visceral fat content and body fat percentage significantly decreased after the intervention [57]. These studies demonstrate the impact of exercise combined with diet on fat indices, but no gender differences were found in different dietary approaches. This study found that in the three dietary approaches, males in the TWF+Ex group showed a greater reduction in fat indices, while females in the LCD+Ex group showed a more significant decrease in fat indices. The DiOGenes trial [35] followed an 8-week LCD (800 kcal/day) and found that after weight loss, the weight loss was more pronounced in males than in females. Post-weight loss, the changes in visceral or abdominal fat in males were more pronounced, while subcutaneous fat in females decreased more significantly, which is opposite to the results of this study. This discrepancy may be due to the intervention protocol or measurement methods.

This study shows that the combination of the three dietary approaches with exercise has a significant effect on fat indices. This is consistent with the vast majority of studies, but differences were found through mean comparisons. Males show better results with the TWF diet combined with exercise, while females show better results with the LCD diet combined with exercise, especially in visceral fat content. Therefore, it is suggested that males may lean towards the TWF diet combined with

exercise during weight loss, and females may lean towards the LCD diet combined with exercise.

Comprehensive Effects of Interventions on Body Composition: Analysis Based on the Interaction of Diet, Time, and Gender

This study further revealed the interaction effects of diet, time, and gender on body composition through a linear mixed model. For instance, in the analysis of body weight, the significant interaction between time and gender indicated that the impact of intervention duration on weight varied by gender, which may be related to biological differences in fat metabolism and hormone levels between males and females [58]. Specifically, the weight of the female group decreased over time, while the male group experienced weight gain at certain time points, suggesting the need for gender-specific personalized weight management strategies. Regarding dietary factors, the slight positive effect of TRF on body weight and visceral fat warrants further investigation into its caloric and nutritional composition.

Additionally, in other aspects of body composition, such as lean body mass and muscle mass, the significant interaction between time and gender reflected that the intervention's effect on lean tissue exhibited gender specificity, which is associated with differences in muscle composition and exercise responsiveness between males and females [59]. These findings provide a basis for precise diet intervention, emphasizing the importance of incorporating gender dimension into health management and dynamically adjusting strategies. Future research can further integrate biochemical indicators and genetic data, explore the molecular mechanism of the interaction between gender, diet and time, and thus optimize personalized intervention strategies.

In terms of the time dimension, the significant negative effects of 4 week and 8 week on body weight, BMI, and subcutaneous fat indicated that prolonged intervention duration effectively improved weight and fat-related indicators, supporting the necessity of long-term interventions. In the interaction between diet and gender, the significant negative effects of LCD:Female, TRF:Female, and TWF:Female on body weight suggested that specific dietary approaches may offer greater advantages for weight management in the female population, potentially due to differences in metabolic characteristics and hormone levels [60-62]. For example, the significant positive effect of LCD:Female on subcutaneous fat may reflect a unique regulatory mechanism of this dietary pattern on subcutaneous fat in females, which requires further investigation into its nutritional composition.

Self-selection of Dietary Regimens: Coexistence of Selection Bias and Practical Application Advantages

In this study, the voluntary selection of intervention groups by participants may have introduced selection bias, which could affect the validity and generalizability of the results. Self-selection bias often arises when participants choose intervention groups based on personal preferences, beliefs, or expectations, potentially leading to baseline differences between groups and confounding the interpretation of

intervention effects. Although the analysis showed no significant differences between groups at baseline, underlying differences in motivation, adherence, or health status may still influence the results. Additionally, the lack of blinding of participants may lead to performance bias and measurement bias. For example, participants may alter their behavior or report outcomes differently based on their knowledge of the intervention group. Such biases are common in non-blinded studies and may compromise the objectivity of the results. However, a potential advantage of self-selection is that it may improve participant adherence. Studies have shown that designs that allow participants to choose diets are more reflective of real-world implementations [63]. Additionally, self-selection of dietary approaches may enhance adherence, making it easier for participants to sustain their chosen regimen and achieve ideal weight loss outcomes. For example, a study on patients with type 2 diabetes (T2DM) demonstrated that allowing patients to choose their diets based on prior experience and dietary guidance exhibited practical applicability and effectiveness in managing T2DM[64].

Therefore, although self-selection and the lack of blinding may introduce bias, their positive impact on adherence is also worth noting. Future research should adopt randomized and blinded designs by balancing the trade-offs between bias and adherence, thereby enhancing the reliability of the study.

The initial phase of weight loss plays a crucial role in shaping future weight management. Although an 8-week intervention is insufficient to evaluate long-term maintenance effects, it provides important insights into short- to medium-term outcomes, which are fundamental and critical for the prevention and control of obesity. This is supported by existing literature. For instance, a recent Meta-Review highlighted that among systematic reviews (n=9) and meta-analyses (n=8) focusing on physical activity (PA) and PA+diet applications, the most common intervention durations were 6 weeks (3/17, 18%) and 8 weeks (3/17, 18%). Specifically, for studies involving PA+diet applications, the most common duration was 8 weeks (3/12, 25%) [65]. This further validates the suitability of our 8-week design in obesity-related intervention research.

Additionally, the relationship between the effects of short-term interventions and long-term weight management has been explored in other studies. For example, some literature suggests that short-term body weight variability (BWV) has potential value in predicting long-term weight changes[66]. Combining these findings, short-term interventions (such as 8 weeks) not only provide significant insights into short- to medium-term outcomes but also lay the foundation for long-term weight management. Although the 8-week intervention period is relatively short, it aligns with the common durations found in the literature and holds certain reference value in predicting long-term weight changes. Therefore, in obesity prevention and control intervention research, the 8-week design is both reasonable and applicable, while long-term monitoring and intervention strategies should also be integrated to achieve more sustainable weight management outcomes.

Study Strengths and study limitations

The present study has the following strengths. First, the innovative integration of digital technology into an obesity intervention and the enhancement of behavioral adherence through SM with FB. Second, the combination of three dietary patterns (TWF, LCD, and TRF) with a standardized exercise regimen enables a direct comparison of intervention effects. Third, this study specifically explored the differential response of men and women to different dietary interventions, laying the foundation for personalized weight management strategies. Fourth, the digital platform of this study achieved a high level of adherence rate and a low dropout rate, validating the feasibility of technology-driven interventions in real-world scenarios. Finally, this study covers body composition metrics (muscle mass, visceral / subcutaneous fat) and longitudinal data analysis, providing dual insights into short-term and long-term effects.

Nevertheless, the following shortcomings need to be noted: First, self-selection could lead to baseline differences between groups (e.g., health awareness, motivation, or baseline health status), which may affect the interpretation of the results. Additionally, participants might adjust their behavior based on their knowledge of the intervention or be influenced by subjective expectations when reporting outcomes, potentially introducing performance and measurement biases. Furthermore, self-selection may be associated with other health behaviors (e.g., exercise or sleep) that could independently influence the results. Future randomized controlled trials (RCTs) are needed to validate the findings. Second, the sample was limited to the youth population, which limits the applicability of the results to the elderly population or clinical scenarios. Third, the 8-week intervention cycle does not allow for extrapolation of the sustainability of long-term effects. Fourth, potential confounders such as psychological factors (e.g., stress, motivation) and lifestyle variables (e.g., sleep quality) were not assessed, which may affect the interpretation of the results.

Conclusions

This study demonstrates that diet and exercise interventions augmented by digital technology are effective in improving body composition in obese college students and differ between genders. For example, men significantly reduced visceral fat with TWF+EX. Women lost more subcutaneous fat with LCD+EX. In addition, SM+FB significantly improved adherence, reduced participant burden, and enhanced intervention effects through real-time feedback mechanisms, thus validating the effectiveness of the closed loop “monitoring-feedback-behavior modification” and highlighting its role as a scalable tool for obesity management. Gender x diet interactions had a significant effect on subcutaneous fat, with LCD being used in women and TRF needing to be combined with protein supplementation. Taken

together, these findings suggest that digital technology shows great potential for obesity management, highlighting the importance of incorporating gender factors into weight loss strategies, and that future research should explore long-term outcomes, older populations, and personalized nutrition-exercise prescriptions.

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Authors' Contributions

Su Liqiang and Hu Chengyuan designed and supervised the study. Lu Zixin, Lai Chunyuan, and Zhu Jieping were responsible for data collection. Hu Chengyuan and Cheng Xiaoyan conducted the data analysis. Guo Dongjuan, Chen Maolin, Rao Mingxin, and Zhou Xinyou critically reviewed the results. The initial draft was written by Hu Chengyuan. All authors contributed to the critical review and editing of the manuscript and approved the final version.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Specific intervention methods (knowledge, exercise, diet, self - monitoring, and feedback)

Multimedia Appendix 2

Intervention Protocol

Multimedia Appendix 3

Comparison of Compliance by Dietary Patterns and Gender During the Intervention Period

Multimedia Appendix 4

Trend charts of changes in fat indicators and muscle indicators

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Abbreviations

TWF: twice-per week fasting diet

LCD::low-calorie diet

TRF: time-restricted feeding

EX:Exercise

SM:Self-monitoring

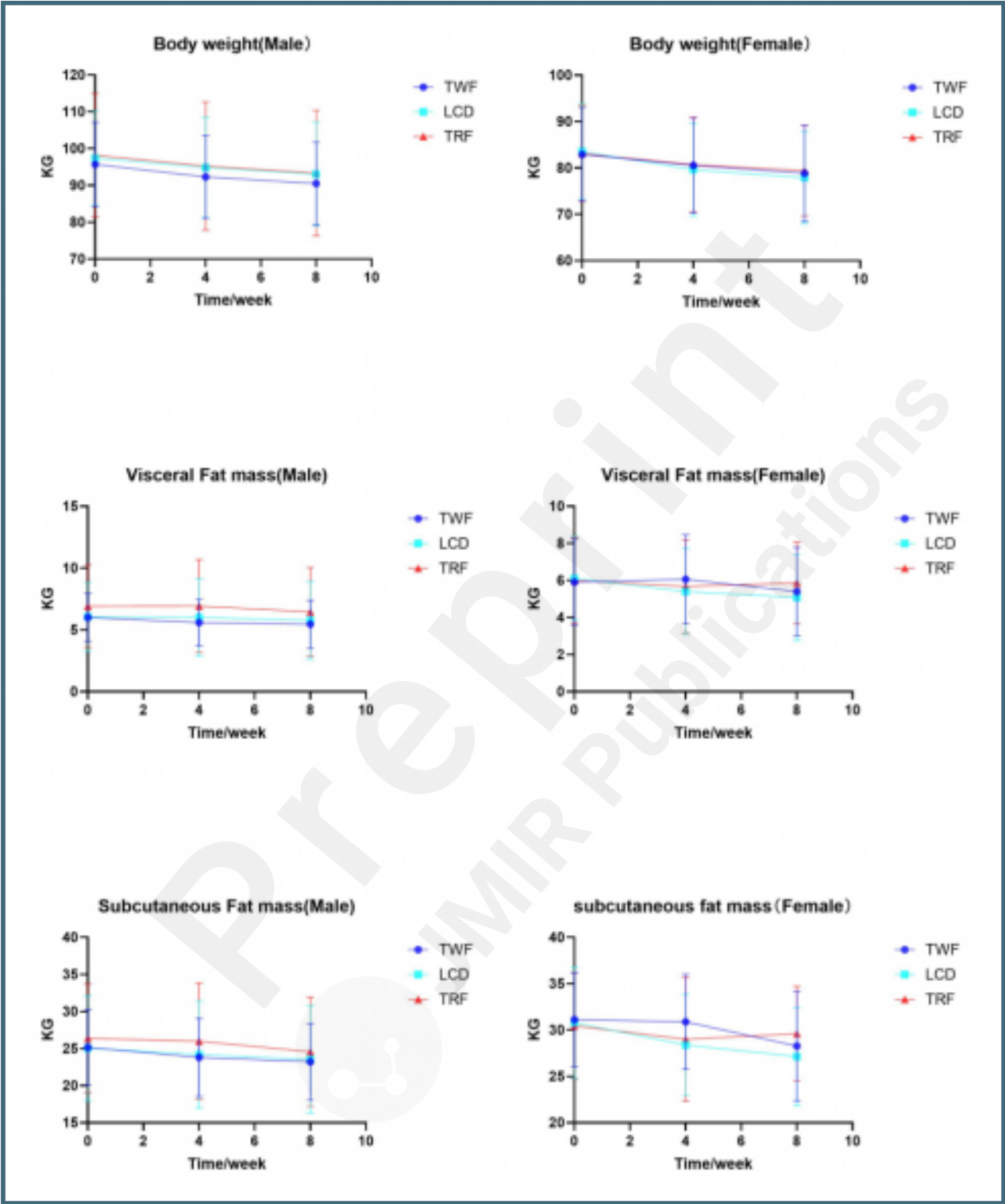
FB:Feedback

MD: mean difference

Supplementary Files

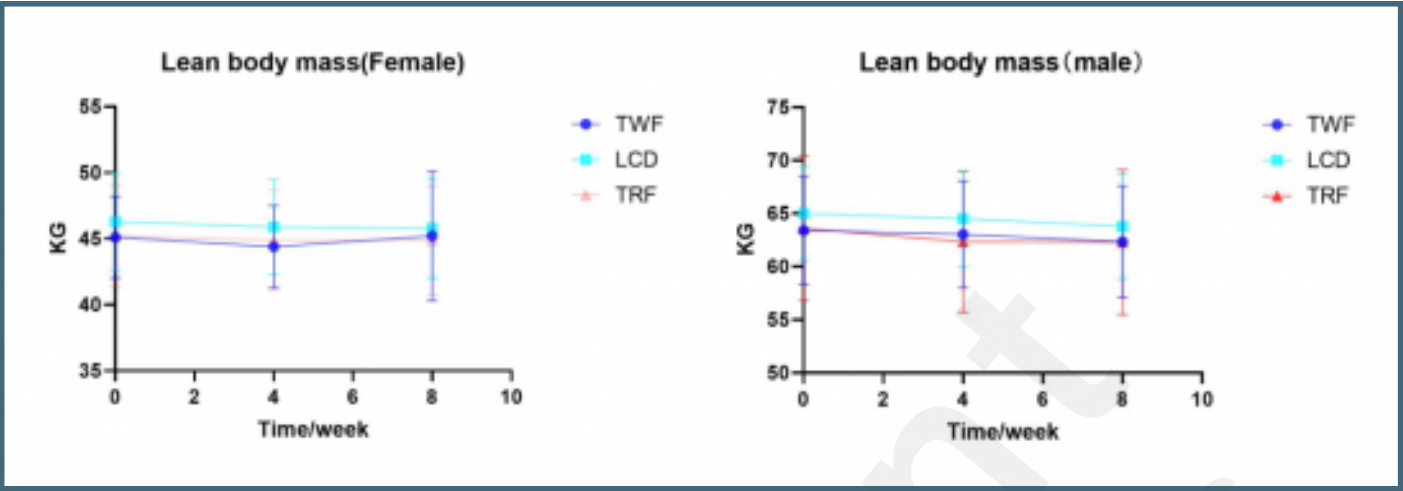
Figures

Untitled.Fat index trend chart.



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Untitled.Muscle index trend chart.



Multimedia Appendixes

Knowledge, exercise, diet, self-monitoring, and feedback intervention are the specific descriptions of this passage.

URL: <http://asset.jmir.pub/assets/61101719e5dc33810483d09fdf3f0370.pdf>

Intervention Protocol.

URL: <http://asset.jmir.pub/assets/b6fd5caa053e0813bcba8c9ce2ac36b.pdf>

Comparison of Compliance by Dietary Patterns and Gender During the Intervention Period.

URL: <http://asset.jmir.pub/assets/52403930e4679a6164fe5d77cace4144.pdf>

Graph of the trends of three groups of muscle and fat indicators over.

URL: <http://asset.jmir.pub/assets/6e07da67da8394176547d2fa288ba863.pdf>

