Study on the Impact of Combined Exercise and Various Dietary Approaches Based on Digital Technology on the Body Composition of Obese College Students

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Abstract

Background: Obesity has become a global health crisis, with projections indicating that by 2030, the number of overweight or obese individuals in China will surge to 790 million. 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: A total of 129 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), a twice-per week fasting diet (TWF), and a 16/8 time-restricted feeding diet (TRF). Changes in body composition indicators (muscle mass, fat mass, and water content) were assessed before and after the intervention. Participants were divided into three groups (LCD, TWF, TRF) for the experiment.

Results: The 8-week intervention led to improvements in the body composition of obese college students. Additionally, it was found that compared to baseline, the male participants in the TWF group experienced a significant reduction in fat indices, and the female participants in the LCD group also showed a significant decrease in fat indices after the 8-week intervention.

Conclusions: In the process of weight loss through the combination of exercise and dieting, using digital technology methods, various dietary approaches combined with exercise have distinct effects on body composition. Among the muscle indices, the TRF group experienced a rapid decrease in lean body mass at four weeks, which remained stable at eight weeks, with a slight increase observed in females. Regarding fat indices, males in the TWF group achieved better fat reduction, while females in the LCD group had a more significant decrease in fat mass. In terms of water content, both males and females in the TWF group maintained better hydration levels. Clinical Trial: Chinese Clinical Trial Registry ChiCTR2300073166

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paper type：Original Paper

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In the process of weight loss through the combination of exercise and dieting, using digital technology methods, various dietary approaches combined with exercise have distinct effects on body composition. Among the muscle indices, the TRF group experienced a rapid decrease in lean body mass at four weeks, which remained stable at eight weeks, with a slight increase observed in females. Regarding fat indices, males in the TWF group achieved better fat reduction, while females in the LCD group had a more significant decrease in fat mass. In terms of water content, both males and females in the TWF group maintained better hydration levels.

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

Trial Registration:

Chinese Clinical Trial Registry ChiCTR2300073166；https://www.chictr.org.cn/showproj.html?proj=189231

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]. It is projected that by 2030, the number of overweight or obese individuals in China will grow 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 globally 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].

In the healthcare 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 [14]. A recent systematic review study indicates [15] 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 levels of effectiveness. For instance, smartphones [16], 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 [17]. 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 [18] et al. shows that compliance with self-monitoring significantly decreases over time during participation in weight loss behavioral treatment programs. Another study indicates [19] that the combination of self-monitoring and feedback (SM + FB) can enhance behavior change. By synchronizing data via smartphones, the need for manual recording of exercise and weight is eliminated, thereby reducing the burden on participants and increasing compliance.

Currently, only two studies have explored the impact of self-monitoring combined with feedback (SM+FB) on weight loss. These research findings suggest that there is no significant difference in weight loss outcomes between SM+FB and self-monitoring alone (SM). However, participants who utilized feedback (FB) demonstrated better compliance and weight loss effects [19, 20]. These studies did not provide specific dietary plans and exercise programs, nor did they conduct phase-based or gender-based comparisons.

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, aiming to improve the health status of obese college students. The study will observe improvements in muscle indices (such as lean body mass, muscle volume, etc.), fat indices (such as visceral fat content, subcutaneous fat content, etc.), and water indices (such as body water, intracellular fluid, 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. 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. 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, fat mass, and water content. Secondly, we hypothesize that, in addition, the intervention measures incorporating digital technology for self-monitoring (SM) and feedback (FB) will demonstrate higher compliance and more significant weight loss outcomes.

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. The method content checklist is provided in Multimedia Appendix 1.

Ethical Considerations

The study was approved by the Ethics Committee of Nanjing Normal University with the ethical code NNU202310007 and was registered at the Chinese Clinical Trial Registry (ChiCTR2300073166). All data were identified by code numbers to ensure the confidentiality of the participants' information. No compensation was provided to the participants.

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

Digital technology approach

The study employs a digital technology intervention approach as a medium, utilizing the WeChat 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.

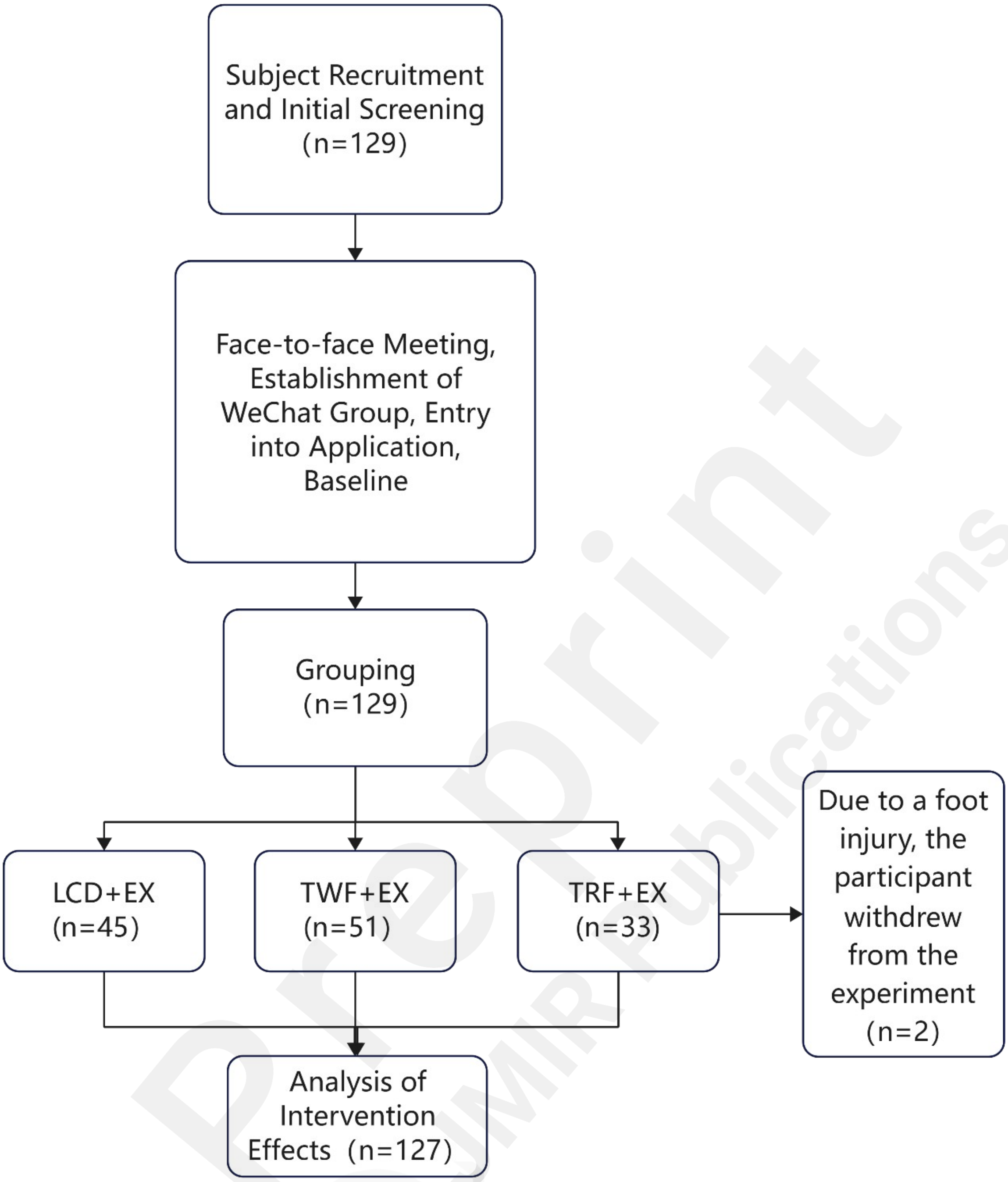

Figure 1 flowchart

Knowledge intervention

During the baseline phase, all participants attended a face-to-face intervention course. Subsequently, the research team demonstrated the use of the WeChat mini-program, including how to monitor diet, physical activity (PA), fill out questionnaires, and set up a WeChat group. Additionally, each week, professionals created PowerPoint presentations covering topics such as prevention of sports injuries, the 5+2 intermittent fasting method, the 16/8 time-restricted eating pattern, low-calorie dieting, the weight loss cycle (from weight reduction to weight maintenance), the correct posture for running, exercise principles, the key role of diet during fat loss, and health knowledge for weight maintenance. The research team shared these PowerPoint presentations within the group for self-study by the participants and required them to submit their learning notes online.

Exercise intervention

The exercise intervention consists of two one-hour intensive training sessions per week, guided by professional coaches. The training regimen is high-intensity interval training, focusing primarily on cardiovascular endurance and strength exercises. Additionally, there is a requirement for at least five sessions of sunlight running per week, each not less than 2 km in distance. All of these activities are recorded and uploaded to the application.

Diet intervention

A low-calorie diet (LCD) refers to a dietary regimen with a total daily caloric intake of 800 Kcal [21]. Intermittent fasting (IF) includes alternate-day fasting (ADF), the twice-per week fasting diet (TWF), and time-restricted feeding (TRF). Given that ADF requires multiple fasting days per week and considering the academic burden of university students, this diet method was excluded from the study. TWF typically involves fasting for 2 days per week, consuming only 300 Kcal per fasting day, and unrestricted eating for the other 5 days. TRF entails a daily fasting period of 12 to 24 hours, with the remaining time allocated for eating; in this study, we selected a 16-hour fasting period and an 8-hour window for unrestricted eating [22]. In this study, participants were allowed to freely choose their diet method, which helped to enhance their compliance.

Monitoring

The WeChat mini-program was primarily used for self-monitoring, where participants could provide feedback on their weekly diet, exercise, and survey responses via their personal smartphones. Dietary feedback included meal intake, recorded once daily; exercise feedback was fixed at twice a week for one hour of exercise each time, including the "Sunshine Run"; the questionnaire was conducted once a week, aiming to help the research team understand the participants' status in order to better tailor feedback to their individual needs.

Feedback

The WeChat group was primarily utilized by the research team to analyze the information uploaded by participants and to provide them with feedback. This feedback comprised a weekly educational session on knowledge, exercise completion, dietary intake, and psychological motivation. The knowledge session covered the principles and methods of the three dietary approaches, knowledge about fat reduction cycles, exercise methods and principles, and prevention of sports injuries. Exercise feedback was based on the analysis of the exercise check-in data submitted by the participants. The research team published the analysis results within the group at 22:00 every day and offered commendations to those who consistently engaged in exercise. Dietary feedback was provided based on the content and images of the participants' daily food intake that were uploaded. For participants who did not meet the dietary standards, the research team issued prompts within the group. In terms of psychological motivation, the research team sent encouraging messages in the WeChat group every day, such as: "Do not back down in the face of difficulties; stand tall, advance bravely, ignite your passion, and shed your sweat. Let fat reduction light up your healthy life. Keep it up!"

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 [23]. They removed their socks and stood on the foot plates, holding the electrode handles, and maintained a fixed posture during the test. Participants entered their height and skin weight (0.5kg) as prompted, and initiated the test following the instrument's instructions. The test data were automatically recorded into the computer for storage. The measurement indices included muscle parameters (lean body mass and muscle mass), fat parameters (body weight, BMI, visceral fat mass, and subcutaneous fat mass), and moisture parameters (total body water, extracellular fluid, and intracellular fluid).

Compliance

Participants were divided into different groups based on their individual diet choices to analyze compliance indicators between the different diet groups. Within each diet group, compliance was defined by the total number of photographs taken during the fasting periods and the total number of exercise check-ins.

Statistical Analysis

Data were analyzed using SPSS version 26.0 statistical software. Outliers were identified using box plots, and the distribution of the data was assessed with the Shapiro-Wilk test. Continuous variables with a normal distribution are presented as mean and standard deviation and were analyzed using one-way ANOVA across the three groups; continuous variables that did not meet the normal distribution are presented as median and interquartile range and were analyzed using the Mann-Whitney U test between the three groups; categorical variables are presented as frequency and composition ratio and were analyzed using the chi-square test. 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 α=0.05, and a P-value less than 0.05 was considered statistically significant.

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 ($P > .04$), 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 ($P = .04$). Tables 1 and 2.

Table 1. Male Basic participant characteristics of the 3 groups.

Indices	TWF+EX(n=18)	LCD+EX(n=29)	TRF+EX(n=15)	*F/X²*	*P*
Age (years)	18.22±0.73	18.45±0.69	18.33±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
Total Body Water(%)	41.74±5.14	42.76±3.34	40.33±4.1	1.735	0.185
Protein (kg)	18.38±2.62	18.89±2.48	19.99±3.03	1.544	0.222
Intracellular Fluid(%)	25.61±3.75	26.19±2.41	24.3±2.65	2.087	0.133
Extracellular Fluid(%)	16.13±1.49	16.57±1.13	16.03±1.56	1.010	0.370

Table 2. Female Basic participant characteristics of the 3 groups.

Indices	TWF+EX(n=33)	LCD+EX(n=16)	TRF+EX(n=16)	F	*P*
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
Total Body Water(%)	34.05±2.74	34.36±3.42	33.84±3	0.123	0.885
Protein (kg)	8.24±1.3	9.09±1.36	8.58±1.13	2.413	0.098
Intracellular Fluid(%)	19.63±1.5	19.78±2.05	19.52±1.78	0.095	0.909
Extracellular Fluid(%)	14.42±1.37	14.58±1.52	14.32±1.54	0.126	0.882

Comparison of Muscle Indices Before and After the Intervention

In the muscle parameters, the one-way ANOVA results showed no significant differences between the groups. Compared to the pre-intervention, both lean body mass and muscle mass decreased in all three groups at 4 and 8 weeks. However, in the TRF group, males experienced a significant reduction in lean body mass ($P < .001$) and muscle mass ($P < .001$) at 4 weeks, with no significant further decrease at 8 weeks compared to 4 weeks ($P = .909$, $P = .867$). See Table 3 and Figure 2.

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*
Man	Lean Body Mass	TWF+EX	63.4±5.1	63.0±5.0	62.3±5.2ab	.107	.003	0.013	-1.056	4.713	.013
		LCD+EX	65±4.43	64.5±4.5a	63.8±4.9ab	.009	□.001	0.001	-1.224	10.049	□.001
		TRF+EX	63.6±6.8	62.3±6.6a	62.3±6.8a	□.001	.001	0.909	-1.293	12.275	□.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	-0.989	4.575	.014
		LCD+EX	61.7±4.2	61.2±4.3a	60.5±4.7ab	.009	□.001	0.001	-0.690	10.021	□.001
		TRF+EX	60.3±6.5	59.1±6.3a	59.1±6.5a	□.001	0.001	0.867	-1.247	12.389	□.001
		F	.640	.973	.538						
		P	.531	.384	.587						
Female	Lean Body Mass	TWF+EX	45.1±3.1*	44.4±3.1#	45.2±4.9&	□.001	.757	.074	.136		
		LCD+EX	46.3±3.7*	45.9±3.6#	45.8±3.8&	.028	.387	.881	-.550		
		TRF+EX	45.2±3.8*	44.9±3.8#	44.9±4.12&	.121	.664	.944	-.275		
		F	0.755	0.968	0.151						
		P	.474	.386	.860						
	Muscle Mass	TWF+EX	42.3±2.8*	41.7±2.8#	42.5±4.6&	□.001	.702	.075	.164	11.211	□.001
		LCD+EX	43.4±3.4*	43.0±3.3#	43.0±3.5&	.031	.422	.893	-.494	2.480	.092
		TRF+EX	42.4±3.5*	42.1±3.5#	42.2±3.8&	.128	.676	.959	-.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: : indicates *P* = .04 compared to group 1; : indicates *P* = .04 compared to group 2;

Gender comparisons: * indicates *P* = .04 compared to male baseline; #: indicates *P* = .04 compared to 4 weeks in males; &: indicates *P* = .04 compared to 8 weeks in males;

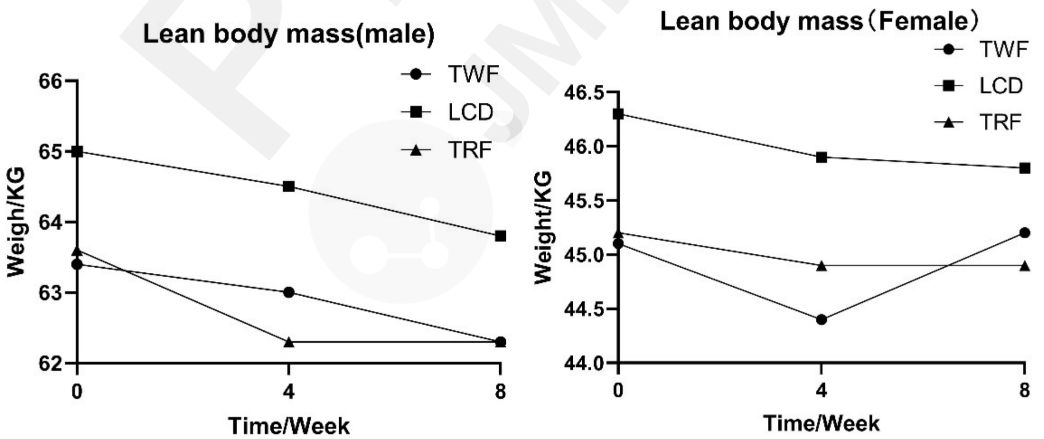

Figure 2. Trend chart of lean body mass in the three groups.

Comparison of Fat Indices Before and After the Intervention

Compared to the pre-intervention, fat indices in all three groups showed a downward trend at 4 and 8 weeks. The results of the repeated measures ANOVA revealed significant differences within groups, except for the visceral fat content and subcutaneous fat content in the TRF group (*P* = .04). Compared to the pre-intervention and 4 weeks, fat indices in males of the TWF group significantly decreased at 8 weeks (*P* = .04), and fat indices in females of the LCD group significantly decreased at both 4 and 8 weeks (*P* = .04). Table 4 and Figure 3.

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

Sex	Indices	Group	0week	4week	8week	0and4 P	0and8 P	8and4 P	8and4 MD	F	P
Male	Body Weight	TWF+EX	95.8±11.4	92.3±11.1a	90.5±11.2ab	<.001	<.001	0.001	-5.233	20.418	<.001
		LCD+EX	97.5±12.9	94.8±13.6a	93.1±14.1ab	<001	<.001	<.001	-4.383	27.853	<.001
		TRF+EX	98.2±16.8	95.3±17.4a	93.3±17.0ab	<.001	<.001	<.001	-4.827	17.373	<.001
		F	.146	.235	.150						
		P	.864	.791	.861						
	BMI	TWF+EX	30.4±3.0	29.7±3.1a	29.0±3.1ab	0.002	<.001	0.003	-1.361	9.516	<.001
		LCD+EX	31.1±3.9	30.7±4.1a	30.1±4.3ab	0.012	<.001	<.001	-1.028	18.905	<.001
		TRF+EX	31.3±3.6	30.9±4.0	30.1±3.9ab	0.115	<.001	<.001	-1.120	13.590	<.001
		F	.308	.484	.257						
		P	.736	.618	.774						
	Visceral Fat mass	TWF+EX	6.01±1.9	5.59±1.9a	5.46±1.9a	0.009	0.003	0.189	-0.556	4.828	.011
		LCD+EX	6.06±2.8	6.02±3.1	5.77±3.1	0.777	0.043	0.003	-0.290	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						
		P	.551	.440	.618						
	Subcutaneous Fat	TWF+EX	25.2±5.1	23.8±5.3a	23.2±5.2ab	<.001	<.001	0.026	-1.922	15.035	<.001
		LCD+EX	25.1±7.1	24.2±7.2a	23.5±7.2ab	<.001	<.001	0.002	-1.528	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						
		P	.805	.630	.837						
Female	Body Weight	TWF+EX	82.9±10.1*	80.5±10.21a#	78.8±10.4ab&	<.001	<.001	<.001	-4.073	41.337	<.001
		LCD+EX	83.6±10.3*	79.6±10.0a#	77.9±9.9ab&	<.001	<.001	.001	-5.662	44.993	<.001
		TRF+EX	83.1±10.4*	80.7±10.2a#	79.4±9.8ab&	<.001	<.001	.012	-3.719	18.193	<.001
		F	0.021	0.058	0.093						
		P	.979	.944	.912						
	BMI	TWF+EX	30.8±3.2	30.7±3.3	29.5±3.5ab	.160	<.001	<.001	-1.303	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						
		P	.379	.144	.289						
	Visceral Fat mass	TWF+EX	5.92±2.3	6.06±2.4	5.40±2.4ab	.434	.016	<.001	-0.515	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	-0.138	0.796	.456
		F	0.040	0.433	0.458						
		P	.961	.650	.635						
	Subcutaneous Fat	TWF+EX	31.1±5.1*	30.9±5.1#	28.3±5.9ab&	.626	<.001	<.001	-2.842	8.521	.001
		LCD+EX	30.8±6.0*	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±5.1&	.039	.402	.545	-0.856	2.194	.120
		F	0.081	1.278	0.775						
		P	.922	.286	.465						

Within-group comparisons: a: indicates *P* = .04 compared to baseline; b: indicates *P* = .04 compared to 4 weeks;

Between-group comparisons: : indicates *P* = .04 compared to group 1; : indicates *P* = .04 compared to group 2;

Gender comparisons: * indicates *P* = .04 compared to male baseline; #: indicates *P* = .04 compared to 4 weeks in males; &: indicates *P* = .04 compared to 8 weeks in males;

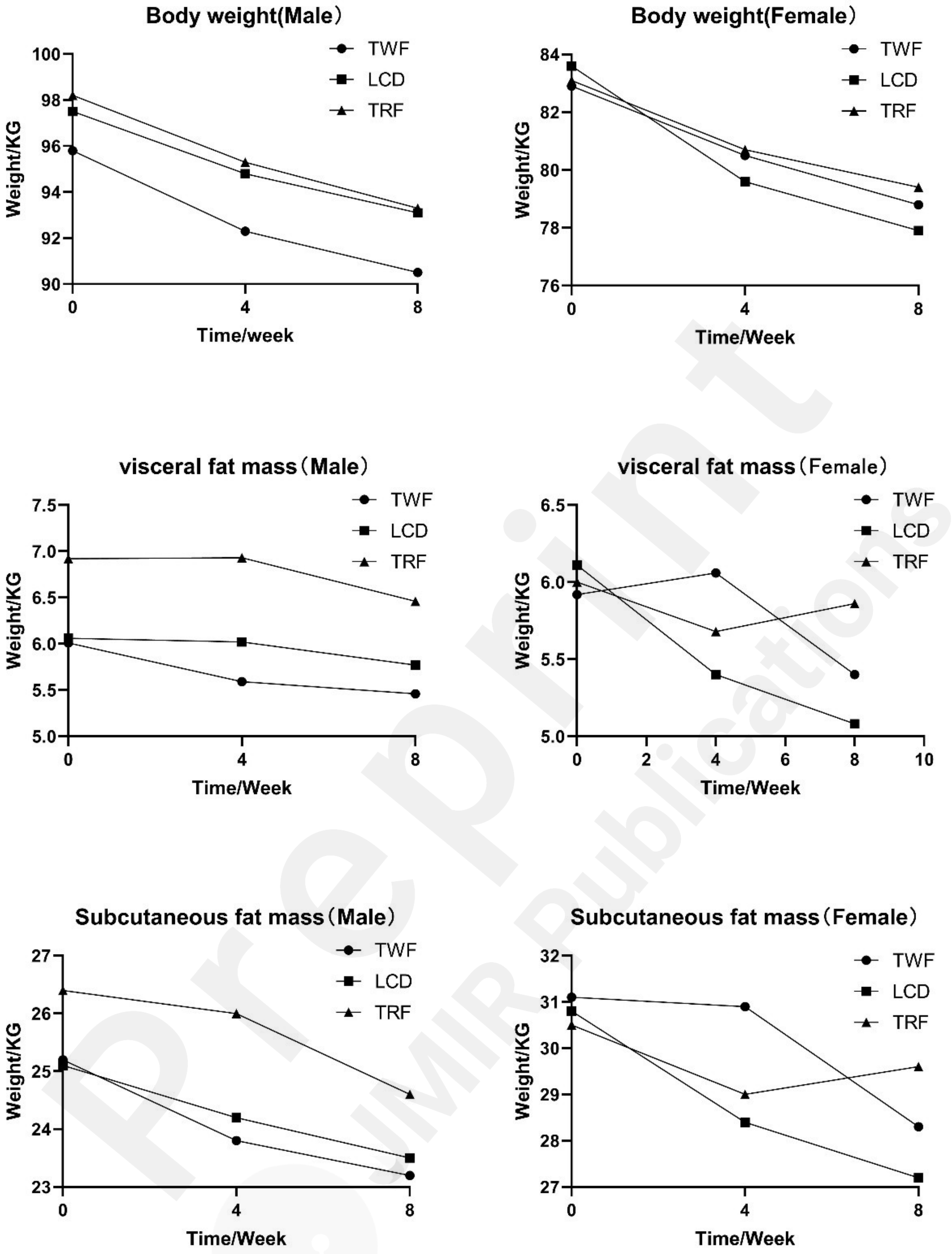

Figure 3. Trend Chart of Body Weight, Visceral Fat mass, and Subcutaneous Fat mass in the Three Groups.

Comparison of Moisture Indices Before and After the Intervention

Compared to the pre-intervention, the moisture indices in all three groups showed a downward trend at 4 and 8 weeks. Independent samples t-tests revealed significant differences between males and females (*P* = .04), with males showing a greater decrease in moisture indices than females. Comparison using mean differences (MD) found that the TRF group preserved moisture better in males (-1.587, *P* = .001), while the TWF group preserved moisture better in females (-0.588, *P* = .001). Table 5 and Figure 4.

Table 5 Comparison of Moisture Indices Among the Three Groups Post-Intervention

Sex	Indices	Group	0week	4week	8week	0and4 P	0and8 P	8and4 P	8and4 MD	F	P
Man	Total Body Water	TWF+EX	41.7±5.1	41.0±5.0	40.3±4.9ab	.018	.001	.035	-1.411	6.343	.003
		LCD+EX	42.7±3.3	41.8±3.4a	40.9±3.4ab	□.001	□.001	.004	-1.879	14.206	□.001
		TRF+EX	40.3±4.1	39.0±4.1a	38.8±3.8a	□.001	.002	.597	-1.587	8.302	.001
		F	1.735	2.351	1.395						
		P	.185	.104	.256						
	Intracellular Fluid	TWF+EX	25.6±3.8	25.0±3.6	24.5±3.6ab	.022	.002	.074	-1.117	5.695	.006
		LCD+EX	26.2±2.4	25.5±2.6a	24.8±2.4ab	.001	□.001	.015	-1.369	11.774	□.001
		TRF+EX	24.3±2.7	23.2±2.6a	23.1±2.3a	□.001	.003	.660	-1.240	7.884	.001
		F	2.087	2.955	2.008						
		P	.133	.060	.143						
	Extracellular Fluid	TWF+EX	16.1±1.5	16.0±1.5a	15.8±1.4ab	.063	.001	.003	-0.294	6.477	.003
		LCD+EX	16.6±1.1	16.3±1.1a	16.1±1.3ab	□.001	□.001	□.001	-0.510	16.511	□.001
		TRF+EX	16.0±1.6	15.8±1.6a	15.7±1.6a	.003	.007	.438	-0.347	5.117	.009
		F	1.010	.974	.480						
		P	.370	.384	.621						
Female	Total Body Water	TWF+EX	34.1±2.7*	33.5±3.1#	33.5±3.62&	□.001	.057	.971	-0.588	7.598	.001
		LCD+EX	34.4±3.4*	33.6±3.1a#	33.5±3.44a&	.001	.054	.837	-0.856	6.277	.003
		TRF+EX	33.8±3.0*	33.4±3.3#	33.1±3.34ab&	.050	.095	.411	-0.738	2.212	.118
		F	.123	.013	.070						
		P	.885	.987	.932						
	Intracellular Fluid	TWF+EX	19.6±1.5*	19.2±1.6#	19.4±2.29&	.002	.257	.504	-0.276	5.685	.005
		LCD+EX	19.8±2.1*	19.4±1.8#	19.5±2.17&	.047	.473	.701	-0.250	2.121	.129
		TRF+EX	19.5±1.8*	19.3±1.9#	19.1±2.1a&	.178	.224	.536	-0.425	1.082	.345
		F	.095	.072	.159						
		P	.909	.930	.853						
	Extracellular Fluid	TWF+EX	14.4±1.4*	14.2±1.6a#	14.1±1.61ab&	.002	□.001	.060	-0.312	7.945	.001
		LCD+EX	14.6±1.5*	14.2±1.5a#	14.0±1.5a&	□.001	□.001	.054	-0.606	16.360	□.001
		TRF+EX	14.3±1.5*	14.1±1.7#	14.0±1.55ab&	.022	.010	.218	-0.313	3.977	.024
		F	.126	.033	.053						
		P	.882	.968	.948						

Within-group comparisons: a: indicates P = .04 compared to baseline; b: indicates P = .04 compared to 4 weeks;
Between-group comparisons: : indicates P = .04 compared to group 1; : indicates P = .04 compared to group 2;
Gender comparisons: * indicates P = .04 compared to male baseline; #: indicates P = .04 compared to 4 weeks in males; &: indicates P = .04 compared to 8 weeks in males;

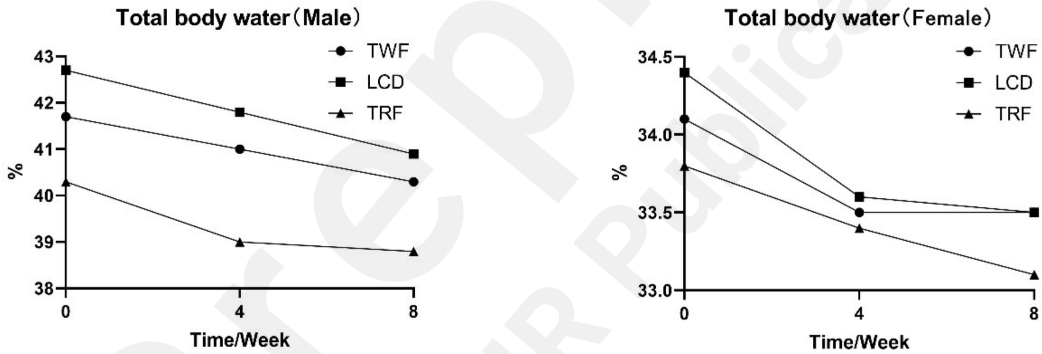

Figure 3.Trend Chart of Body Water Content in the Three Groups.

Discussion

Principal Findings

This study, using digital technology as a medium, investigated its impact on the body composition of obese university students. The results indicate that participants experienced an average weight loss of 5.05%, with the maximum weight loss reaching 14.4%. A total of 118 individuals achieved weight loss, with a dropout rate of only 2.58%. Currently, both domestically and internationally, the approach to addressing obesity widely involves health guidance strategies for weight loss, including face-to-face guidance and paper record-keeping (PR) methods [9-12]. However, PR methods lack timely external feedback, which somewhat limits their effectiveness in providing continuous support and motivation, thereby affecting participant compliance. Digital intervention methods offer new possibilities for enhancing self-monitoring (SM), helping to expand the reach of interventions and prevent declines in compliance. This method serves as an effective complement to face-to-face interventions, eliminating the need for manual recording of physical activity (PA) and weight through the synchronization of data from wearable activity trackers, smart scales, and smartphones. This significantly reduces the burden on participants and markedly increases their engagement and compliance [24, 25]. Nevertheless, the effectiveness of this method can be compromised without feedback (FB). A study has shown [26] that a method combining self-monitoring and feedback (SM+FB) has yielded positive results in improving the lifestyle of patients with coronary heart disease. Therefore, this study employed a digital technology intervention, utilizing smart devices and real-time feedback, which significantly enhanced the weight management outcomes and compliance of obese university students, with an average weight loss of 5.05% and a dropout rate of only 2.58%. This approach effectively complements traditional health guidance strategies, providing an innovative pathway for improving obesity interventions.

The study explored the impact of three dietary approaches (TRF, TWF, LCD) combined with exercise on the body composition of obese university students, utilizing digital technology for self-monitoring and real-time feedback. The results revealed that all three dietary methods combined with exercise effectively reduced indicators such as body weight, body fat percentage, and fat mass. Comparison between the three groups did not show significant differences, indicating that no single dietary approach was significantly superior to the others. However, a comparison of the means revealed some differences across different intervention phases and genders, suggesting that different stages and genders might benefit more from different combinations of diet and exercise.

Comparison With Prior Work

Muscle Indices

This study found that males in the TRF group exhibited phase-specific changes in lean body mass. Literature reviews [4, 27, 28] have indicated that during weight loss, the reduction in lean body mass typically accounts for 20% to 30% of the total weight loss, and males experience three times the loss of lean body mass compared to females [29], suggesting that lean body mass is lost during weight reduction, but which dietary method results in the most loss, and when does this occur? One study's results [30] showed that subjects undergoing the TRF regimen (4 weeks) experienced significant weight loss ($p < 0.05$), with the weight loss primarily due to a reduction in lean body mass rather than fat mass; a systematic review including six observational studies lasting 4 to 8 weeks [31] revealed that TRF participants lost more weight but also lost more lean body mass, indicating a greater reduction in lean body mass with TRF in the short term. Gabel et al. [32] found no significant change in lean body mass after a 12-week 8h TRF intervention; Christopher J Kotarsky et al. [33] conducted an RCT and found no change in lean body mass after eight weeks of TRF combined with resistance training, suggesting that beyond 8 weeks, lean body mass may not change significantly.

These studies demonstrate that TRF affects lean body mass during weight loss, but no trend of phase-specific changes in lean body mass was identified. Based on the theory of self-behavior monitoring, this study aimed to explore the mechanisms of phase-specific changes in muscle indices from the perspective of combining three dietary methods with exercise. We found that in the TRF group, lean body mass decreased rapidly at four weeks and remained largely stable at eight weeks, with females even showing a slight increase. This study speculates that TRF combined with exercise may be beneficial for muscle health in the long term and leads to rapid decline in the short term, though the mechanism remains undiscovered. Therefore, more long-term randomized controlled trials and metabolic studies are needed to uncover this mechanism. However, the findings of this study can provide targeted dietary guidance for the obese population.

Fat Indices

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 [34], and both total fat mass and visceral fat accumulation are closely associated with the occurrence of cardiovascular diseases, stroke, hypertension, and insulin resistance [35-37]. Effective interventions to reduce visceral fat in obese individuals can improve health. Previous systematic reviews and meta-analyses have confirmed [38-41] 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 [42]. 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 [21] 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.

Through this study, it is found 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.

Water Indices

This study found that both male and female participants experienced a decrease in water indices after the intervention. The decrease in water content was more pronounced in males compared to females. Overall, there was a larger reduction in water content at four weeks, with the amount of water loss decreasing at eight weeks, indicating a trend of phase-specific changes. Among the three groups, the TWF group showed better water retention. Fasting induces more rapid weight loss, but most of the tissue loss is body water. Several studies [43, 44] have measured greater water loss at the start of the fasting period, which is attributed to glycogen loss and electrolyte imbalance. Barnard et al. [45] studied 7 severely obese male patients fasting for 10 weeks and found that intracellular fluid (ICW) accounted for 22% ± 8% of the weight change. Compared to previous studies, this study showed a more significant loss of ICW in males, with an average decrease of 27%, and 31.8% in the LCD group. This may be due to the different intervention protocols. A 6-month personalized low-calorie diet plan combined with exercise study [42] showed no change in body water and intracellular and extracellular fluid. A 6-week LCD experiment in males [46] found that the more weight loss, the greater the water loss, especially in ICW, which was five times the weight loss in the early stage. This trend is consistent with the results of this study, suggesting that short-term fasting for weight loss leads to more water loss, and once the fasting period extends, the water loss may decrease. However, which dietary approach is relatively better at maintaining water retention?

Therefore, this study, through the comparison of means of the three dietary approaches, found that both male and female participants showed better water retention with the TWF diet combined with exercise. The association of TWF with water retention is not supported by many direct studies. However, it can be speculated from some characteristics of this diet pattern and related health impacts. TWF is a weight loss method that emphasizes low-calorie intake for two days a week (usually 300-600 calories), with normal diet on the remaining five days. This pattern of calorie intake instability may lead to metabolic adaptation between low-calorie and normal days, which may affect the body's water balance. It should be noted that these assumptions and speculations have not been fully experimentally validated. Currently, there is limited research on the impact of TWF on water retention. More long-term randomized controlled trials and metabolic studies are necessary to comprehensively assess the impact of TWF on body water balance.

Study Sstrengths and study limitations

The main advantage of this study lies in the use of digital technology as the research medium, the combination of SM and FB methods, the comprehensive evaluation of various dietary habits, and the focus on multiple health indicators. The study particularly explores gender differences and maintains a low participant attrition rate. However, this study also has certain limitations. First, due to the main study subjects being college students with heavy academic burdens, random grouping was not implemented but rather grouping was based on the participants' self-choice. Second, since all participants are young people, our research results may not apply to all age groups. In particular, the feasibility and acceptability of digital intervention measures in the elderly population may differ from those in the younger population.

Conclusions

The results of this study indicate that the combination of three dietary approaches with exercise can effectively reduce the body weight and body fat percentage of obese university students. The application of digital technology methods, namely self-monitoring and real-time feedback through smartphones, significantly improves the compliance and effectiveness of the intervention measures, thereby enhancing the weight loss effect. In terms of muscle indices, TRF combined with exercise may be beneficial for muscle health in the long term. In terms of fat indices, men achieve better fat loss effects, especially in visceral fat content, under the TRF combined with exercise program; women achieve better fat loss effects under the LCD diet combined with exercise program. In terms of water indices, the TRF combined with exercise program shows the best effect in water retention. Future research can further explore the mechanism of water retention in TWF and assess its long-term effects and safety. As a novel intervention method, digital technology has broad prospects for application in the field of obesity intervention and is worth further exploration and promotion.

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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

Table: Entire Experimental Plan Process

Multimedia Appendix 2

Intervention Process Images

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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

Supplementary Files

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