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The Effect of Internet-Based Dietary, Exercise, and Combined Interventions on Fat Loss in Overweight and Obese College Students: A Randomized Controlled Trial

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Abstract

Objective: Exploring the effects of Internet-based diet, exercise, and combined interventions on fat loss outcomes in overweight and obese college students. **Method:** College student volunteers were recruited in October 2023 at a university in Luoyang City and divided into 4 groups according to body fat percentage: control group, dietary intervention group, exercise intervention group, and diet-combined exercise intervention group, with 35 people in each group. A 6-week online nutrition and/or exercise intervention was conducted to observe the changes in body composition indexes before and after the intervention in each group. Multiple linear regression was used to explore the influencing factors affecting the effect of fat loss. **Result:** Six people were lost to follow-up, and a total of 134 people eventually completed the trial. Prior to the intervention, none of the differences in baseline characteristics of the groups were statistically significant ($P > 0.05$). Multiple linear regression showed that, compared to the control group, body fat percentage was significantly reduced by 2.18% (95% CI: −3.06 to −1.30, $P < 0.001$) in the combined intervention group and by 1.13% (95% CI: −2.00 to −0.26, $P = 0.012$) in the dietary intervention group, while there was no statistically significant difference in the exercise intervention group ($P = 0.317$). Female ($\beta = -0.33\%$, $P = 0.039$), baseline body fat ($\beta = -0.13\%$/kg, $P = 0.040$), and Waist-to-Hip Ratio ($\beta = -12.82\%$/unit, $P = 0.018$) were independent predictors of lower body fat percentage (model $R^2 = 0.336$). **Conclusion:** Internet-based dietary and/or exercise interventions can effectively reduce body fat mass and body fat percent-

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age in overweight and obese college students and are suitable for replication in the obese population.

Keywords

College Students, Internet, Overweight, Obesity, Intervention

1. Introduction

Over the past four decades, China has experienced rapid economic growth, globalization, and urbanization, and the prevalence of overweight and obesity in China has been steadily increasing since the 1990s, and, today, China is home to the largest number of overweight and obese people [1] [2]. Obesity has numerous adverse effects on health, increasing the risk of chronic non-communicable diseases (NCDs) such as type 2 diabetes and cancer, in addition to increasing general mortality [3] [4]. The results of the 8th National Student Physical Fitness and Health Survey, released in 2021, showed that overweight and obesity rates among Chinese college students have continued to rise, and their physical fitness has declined [5]. As the backbone of social development, college students' health problems need to be highly emphasized.

Lifestyle interventions are currently considered to be a safe and effective way to manage overweight and obesity, including dietary interventions, exercise interventions, and psycho-cognitive interventions. Some studies have found that Internet-based online lifestyle interventions have good results for overweight and obese populations and can achieve the purpose of reducing body mass and obesity-related complications [6]-[8]. However, few existing studies have conducted lifestyle interventions for college students, and most of the existing studies classify overweight and obesity based on the body mass index (BMI). BMI can only reflect the weight of the whole body and cannot distinguish between muscle and fat, while body fat percentage can reflect the proportion of fat in the body. A high body fat percentage is not only associated with a higher risk of all-cause mortality but is also prone to complicating the risk of hypertension, hyperlipidemia, coronary artery disease and other diseases: hypertension, hyperlipidemia, coronary heart disease, diabetes mellitus and other chronic diseases [9] [10]. In this sense, body fat percentage may be more suitable than BMI as an indicator for evaluating overweight and obesity.

The 53rd Statistical Report on the Development of the Internet in China shows that by December 2023, the number of Internet users in China reached 1.092 billion, and the Internet penetration rate reached 77.5% [11]. Traditional interventions often require a lot of human and material resources, and Internet-based interventions may be twice as effective with half the effort [12] [13]. Therefore, this study recruited college students with excessive body fat percentage and conducted online exercise and nutrition interventions for them, aiming to explore the effects

of Internet-based online interventions on the fat loss effects of college students with excessive body fat percentage.

2. Objects and Methods

2.1. Objects

In this study, 252 students who were willing to participate were recruited in the form of posters, leaflets, and radio broadcasts to publicize the project at a university in Luoyang City in October 2023, and they were analyzed for body composition. Inclusion criteria: 1) body fat percentage > 20% for males and >28% for females (as determined by the instruction manual of the Inbody-260, the body composition analyzer used in this experiment); 2) not having been on a restrictive diet in the 6 months prior to the start of the study. Exclusion criteria: 1) diagnosis of diabetes mellitus, prior ischemic heart disease, cerebrovascular disease, or severe mental illness; 2) physical impairment that prevents participation in physical activity; 3) receipt of any weight-loss treatment elsewhere; and 4) inaccessibility to the Internet. The study was approved by the Ethics Committee of the 989th Hospital of the Joint Logistics Department of the Chinese People's Liberation Army, and all methods were performed in accordance with relevant guidelines and regulations. All participants signed an informed consent form.

2.2. Sample Size

Internet-based diet, exercise, and combined intervention for overweight and obese college students; pre-intervention body fat is 27.3 kg; hope that after the intervention, the average reduction is 0.7 kg; the standard deviation of the estimated difference is 1.2 kg; take $\alpha = 0.05$ (two-sided), power = 90%, two-sided test, according to the formula for calculating the sample size:

$$n = \frac{\left(z_{\alpha} + z_{\beta}\right)^2 * \sigma^2}{\delta^2}$$

can be obtained as $n = 31$ cases, because of its own matched-pair design, so there is no need to. The sample size was doubled, taking into account 10% lost visits as well as refusals, totaling at least 34 study cases, which were included.

2.3. Randomized Grouping

The recruited subjects were divided into four groups according to the simple randomized grouping method: control group, dietary intervention group, exercise intervention group, and diet-combined exercise intervention group, with 35 subjects in each group.

2.4. Intervention Methodology

2.4.1. Pre-Intervention Preparation

All study subjects underwent anthropometric compositional measurements prior to the intervention, which were performed using an Inbody-260 body composi-

tion analyzer. Subjects fasted for at least 2 h before the test, emptied their bowels, wore light clothing and were prohibited from strenuous activities. During the body composition measurement, the subject stood barefoot on the footplate electrode and held the hand electrode with both hands. The measurer first recorded the subject's basic personal information, such as age and gender, and then carried out the measurement, and the system automatically generated various body composition parameters of the subject. After the measurement was completed, there was an exchange with a nutritionist, who popularized nutritional knowledge and weight reduction methods to the subject, and formulated individualized diet and exercise recommendations for him/her based on the results of the body composition analysis.

2.4.2. Intervention Programs

1) Dietary regimen: Adopt the energy-limited balanced diet method, individualize the calculation of one day's energy demand, and, on the basis of this energy, reduce the total energy intake by 500 - 1000 kcal or by 30% per day.

2) Exercise program: 150 - 300 minutes of moderate-intensity aerobic exercise per week, 5 - 7 days per week, at least once every other day; resistance exercise 2 - 3 days per week, once every other day, 10 - 20 minutes each time. Energy consumption through exercise is 2000 kcal or more per week.

3) Management team: Clinical dietitians, rehabilitators, and counselors with more than 5 years of clinical experience work together to develop individualized diet and exercise plans for students, answer questions, and provide psychological guidance.

4) Follow-up program: Four WeChat group chats were established after random grouping. Subjects independently carried out weight management according to the individualized diet and exercise recommendations and clocked in daily in the WeChat group. The researchers answered the subjects' questions about weight management in the group at any time, and the intervention time was 6 weeks.

2.5. Statistical Analysis

The study was statistically processed using SAS 9.1 and SPSS 21.0 statistical software, with normally distributed measures expressed as mean ± standard deviation ($\bar{x} \pm s$), non-normally distributed measures expressed as median (interquartile spacing), and counts expressed as number of cases (percentage) [n (%)]. Differences in baseline characteristics between groups were analyzed using ANOVA or chi-square tests. When evaluating the effect of intervention, data that did not conform to a normal distribution were log-transformed to make them normally or approximately normally distributed; a paired t-test was used to compare the amount of within-group changes in each index before and after intervention; a multiple linear regression model was used to further explore the relevant factors affecting the changes in body fat percentage and to draw forest plots. All of the above tests were two-sided, and the test level was $\alpha = 0.05$.

3. Results

3.1. Basic Characteristics of the Study Population

There were a total of 134 people in this study, including 35 in the control group (26.12%), 32 in the combined intervention group (23.88%), 34 in the dietary intervention group (25.37%), and 33 in the exercise intervention group (24.63%) according to the intervention modality. The differences in age, height, weight, and gender among the 4 groups were not statistically significant ($P > 0.05$). See Table 1.

Table 1. Basic characteristics of the study subjects in each group.

Variables	Total (n = 134)	Control Group (n = 35)	Joint Intervention Group (n = 32)	Dietary Intervention Group (n = 34)	Exercise Intervention Group (n = 33)	Statistic	*P*
Age, Mean ± SD	19.27 ± 1.09	19.34 ± 1.06	19.34 ± 1.10	19.06 ± 1.10	19.33 ± 1.14	F = 0.56	0.645
Height, Mean ± SD	165.11 ± 6.27	166.23 ± 6.76	165.09 ± 5.73	163.50 ± 7.00	165.61 ± 5.30	F = 1.19	0.315
Weight1, Mean ± SD	67.68 ± 13.59	68.17 ± 17.97	70.00 ± 11.54	64.13 ± 12.83	68.57 ± 10.31	F = 1.15	0.332
Sex, n (%)						$\chi^2 = 1.73$	0.630
Man	26 (19.40)	9 (25.71)	5 (15.62)	5 (14.71)	7 (21.21)		
Woman	108 (80.60)	26 (74.29)	27 (84.38)	29 (85.29)	26 (78.79)		

F: ANOVA; χ^2: Chi-square test. SD: standard deviation.

3.2. Evaluation of the Effect of the Intervention on the Study Population

Paired t-tests revealed significant within-group changes in body composition indicators following the 12-week intervention period, as detailed in Table 2.

Table 2. Within-group comparison of body composition indicators before and after intervention.

norm	Mean 1 ± SD 1	Mean 2 ± SD 2	Difference (95% CI)	t	*P*
BMI (kg/m²)					
Control Group	24.434 ± 5.015	24.626 ± 4.970	−0.191 (−0.304, −0.079)	−3.467	0.001
Joint Intervention Group	25.578 ± 3.603	24.578 ± 3.065	1.000 (0.656, 1.344)	5.927	<0.001
Dietary Intervention Group	23.894 ± 4.059	23.491 ± 3.871	0.403 (0.239, 0.567)	4.999	<0.001
Exercise Intervention Group	24.900 ± 2.936	24.509 ± 2.822	0.391 (0.210, 0.572)	4.402	<0.001

Continued

Body Fat (kg)					
Control Group	23.403 ± 9.322	23.480 ± 9.398	−0.077 (−0.384, 0.229)	−0.511	0.612
Joint Intervention Group	25.225 ± 6.629	22.419 ± 5.290	2.806 (1.736, 3.876)	5.348	<0.001
Dietary Intervention Group	22.841 ± 7.064	21.791 ± 6.784	1.050 (0.661, 1.439)	5.488	<0.001
Exercise Intervention Group	23.352 ± 4.649	22.567 ± 4.341	0.785 (0.240, 1.330)	2.933	0.006
BFR (%)					
Control Group	33.643 ± 4.491	33.557 ± 4.487	0.086 (−0.338, 0.509)	0.411	0.683
Joint Intervention Group	35.638 ± 5.198	33.219 ± 4.598	2.419 (1.394, 3.444)	4.812	<0.001
Dietary Intervention Group	35.074 ± 4.997	33.921 ± 5.017	1.153 (0.585, 1.721)	4.127	<0.001
Exercise Intervention Group	34.182 ± 4.842	33.645 ± 4.776	0.536 (−0.095, 1.168)	1.731	0.093
WHR					
Control Group	0.872 ± 0.043	0.884 ± 0.045	−0.012 (−0.018, −0.006)	−3.785	<0.001
Joint Intervention Group	0.886 ± 0.052	0.857 ± 0.041	0.029 (0.013, 0.046)	3.554	0.001
Dietary Intervention Group	0.866 ± 0.053	0.872 ± 0.050	−0.007 (−0.016, 0.002)	−1.566	0.127
Exercise Intervention Group	0.881 ± 0.039	0.886 ± 0.044	−0.005 (−0.015, 0.004)	−1.118	0.272
Striated Muscle (kg)					
Control Group	24.577 ± 5.727	24.769 ± 5.675	−0.191 (−0.372, −0.011)	−2.153	0.039
Joint Intervention Group	24.609 ± 4.070	24.909 ± 4.350	−0.300 (−0.645, 0.045)	−1.772	0.086
Dietary Intervention Group	22.391 ± 4.079	22.432 ± 3.877	−0.041 (−0.317, 0.235)	−0.303	0.763
Exercise Intervention Group	24.915 ± 5.166	24.873 ± 5.308	0.042 (−0.257, 0.342)	0.288	0.775

Body Mass Index (BMI): All intervention groups demonstrated significant reductions in BMI (all $P < 0.001$). The Joint Intervention Group exhibited the largest decrease (Mean Difference [MD] = 1.000 kg/m^2, 95% CI: 0.656 to 1.344, t = 5.927),

followed by the Dietary Intervention Group (MD = 0.403 kg/m^2, 95% CI: 0.239 to 0.567, t = 4.999) and the Exercise Intervention Group (MD = 0.391 kg/m^2, 95% CI: 0.210 to 0.572, t = 4.402). In contrast, the Control Group experienced a small but statistically significant increase in BMI (MD = −0.191 kg/m^2, 95% CI: −0.304 to −0.079, t = −3.467, $P = 0.001$). Body Fat Mass (kg): Significant reductions in body fat mass were observed in the Joint Intervention Group (MD = 2.806 kg, 95% CI: 1.736 to 3.876, t = 5.348, $P < 0.001$), the Dietary Intervention Group (MD = 1.050 kg, 95% CI: 0.661 to 1.439, t = 5.488, $P < 0.001$), and the Exercise Intervention Group (MD = 0.785 kg, 95% CI: 0.240 to 1.330, t = 2.933, $P = 0.006$). The reduction was largest in the Joint Intervention Group. No significant change occurred in the Control Group (MD = −0.077 kg, 95% CI: −0.384 to 0.229, t = −0.511, $P = 0.612$). Body Fat Rate (BFR %): Both the Joint Intervention Group (MD = 2.419%, 95% CI: 1.394 to 3.444, t = 4.812, $P < 0.001$) and the Dietary Intervention Group (MD = 1.153%, 95% CI: 0.585 to 1.721, t = 4.127, $P < 0.001$) showed significant reductions in body fat percentage. The reduction in the Exercise Intervention Group approached but did not reach statistical significance (MD = 0.536%, 95% CI: 0.095 to 1.168, t = 1.731, $P = 0.093$). The Control Group showed no significant change (MD = 0.086%, 95% CI: −0.338 to 0.509, t = 0.411, $P = 0.683$). Waist-to-Height Ratio (WHR): Changes in WHR varied significantly between groups. The Joint Intervention Group showed a significant improvement (decrease) in WHR (MD = 0.029, 95% CI: 0.013 to 0.046, t = 3.554, $P = 0.001$). Conversely, the Control Group showed a significant increase (worsening) in WHR (MD = −0.012, 95% CI: −0.018 to −0.006, t = −3.785, $P < 0.001$). Neither the Dietary Intervention Group (MD = −0.007, 95% CI: −0.016 to 0.002, t = −1.566, $P = 0.127$) nor the Exercise Intervention Group (MD = −0.005, 95% CI: −0.015 to 0.004, t = −1.118, $P = 0.272$) exhibited significant changes in WHR. Skeletal Muscle Mass (kg): No significant increases in skeletal muscle mass were found in any intervention group (Joint: MD = −0.300 kg, $P = 0.086$; Dietary: MD = −0.041 kg, $P = 0.763$; Exercise: MD = 0.042 kg, $P = 0.775$). The Control Group exhibited a small but statistically significant decrease (MD = −0.191 kg, 95% CI: −0.372 to −0.011, t = −2.153, $P = 0.039$).

Intergroup analyses of change scores (post-intervention minus baseline) revealed significant differences between the intervention groups across multiple body composition indicators (Table 3).

Table 3. Intergroup comparison of body composition indicators before and after intervention.

y	Group 1	Group 2	n1	n2	*P*
BMI2 - BMI1	Control Group	Joint Intervention Group	35	32	**<0.001**
BMI2 - BMI1	Control Group	Dietary Intervention Group	35	34	**<0.001**
BMI2 - BMI1	Joint Intervention Group	Dietary Intervention Group	32	34	**<0.001**

Continued

BMI2 - BMI1	Control Group	Exercise Intervention Group	35	33	**<0.001**
BMI2 - BMI1	Joint Intervention Group	Exercise Intervention Group	32	33	**<0.001**
BMI2 - BMI1	Dietary Intervention Group	Exercise Intervention Group	34	33	0.935
Body Fat2 - Body Fat1	Control Group	Joint Intervention Group	35	32	**<0.001**
Body Fat2 – Body Fat1	Control Group	Dietary Intervention Group	35	34	**0.010**
Body Fat2 - Body Fat1	Joint Intervention Group	Dietary Intervention Group	32	34	**<0.001**
Body Fat2 - Body Fat1	Control Group	Exercise Intervention Group	35	33	**0.049**
Body Fat2 - Body Fat1	Joint Intervention Group	Exercise Intervention Group	32	33	**<0.001**
Body Fat2 - Body Fat1	Dietary Intervention Group	Exercise Intervention Group	34	33	0.546
BFR2 - BFR1	Control Group	Joint Intervention Group	35	32	**<0.001**
BFR2 - BFR1	Control Group	Dietary Intervention Group	35	34	**0.024**
BFR2 - BFR1	Joint Intervention Group	Dietary Intervention Group	32	34	**0.009**
BFR2 - BFR1	Control Group	Exercise Intervention Group	35	33	0.341
BFR2 - BFR1	Joint Intervention Group	Exercise Intervention Group	32	33	**<0.001**
BFR2 - BFR1	Dietary Intervention Group	Exercise Intervention Group	34	33	0.197
WHR2 - WHR1	Control Group	Joint Intervention Group	35	32	**<0.001**
WHR2 - WHR1	Control Group	Dietary Intervention Group	35	34	0.481
WHR2 - WHR1	Joint Intervention Group	Dietary Intervention Group	32	34	**<0.001**
WHR2 - WHR1	Control Group	Exercise Intervention Group	35	33	0.361
WHR2 - WHR1	Joint Intervention Group	Exercise Intervention Group	32	33	**<0.001**
WHR2 - WHR1	Dietary Intervention Group	Exercise Intervention Group	34	33	0.830

Continued

Striated Muscle2 - Striated Muscle1	Control Group	Joint Intervention Group	35	32	0.576
Striated Muscle2 - Striated Muscle1	Control Group	Dietary Intervention Group	35	34	0.432
Striated Muscle2 - Striated Muscle1	Joint Intervention Group	Dietary Intervention Group	32	34	0.186
Striated Muscle2 - Striated Muscle1	Control Group	Exercise Intervention Group	35	33	0.225
Striated Muscle2 - Striated Muscle1	Joint Intervention Group	Exercise Intervention Group	32	33	0.083
Striated Muscle2 - Striated Muscle1	Dietary Intervention Group	Exercise Intervention Group	34	33	0.666

BMI Change: The Joint Intervention Group demonstrated significantly greater BMI reductions than all other groups: Control Group ($P < 0.001$), Dietary Intervention Group ($P < 0.001$), and Exercise Intervention Group ($P < 0.001$). While the Dietary and Exercise Intervention Groups both showed significantly greater reductions than the Control Group (both $P < 0.001$), their effects did not differ significantly from each other ($P = 0.935$). Body Fat Mass Change: The Joint Intervention Group achieved significantly larger body fat reductions than the Control Group ($P < 0.001$), Dietary Intervention Group ($P < 0.001$), and Exercise Intervention Group ($P < 0.001$). Both the Dietary ($P = 0.010$) and Exercise ($P = 0.049$) Intervention Groups showed significantly greater fat loss than the Control Group. No significant difference existed between the Dietary and Exercise Groups ($P = 0.546$). Body Fat Rate (BFR) Change: The Joint Intervention Group produced significantly greater BFR reductions than the Control Group ($P < 0.001$), Dietary Intervention Group ($P = 0.009$), and Exercise Intervention Group ($P < 0.001$). The Dietary Intervention Group showed significantly greater BFR reduction than the Control Group ($P = 0.024$), while the Exercise Group did not ($P = 0.341$). The difference between the Dietary and Exercise Groups was non-significant ($P = 0.197$). Waist-to-Height Ratio (WHR) Change: The Joint Intervention Group exhibited significantly greater WHR improvements (reductions) than the Control Group ($P < 0.001$), Dietary Intervention Group ($P < 0.001$), and Exercise Intervention Group ($P < 0.001$). Neither the Dietary ($P = 0.481$) nor the Exercise ($P = 0.361$) Intervention Group differed significantly from the Control Group. No difference existed between the Dietary and Exercise Groups ($P = 0.830$). Skeletal Muscle Mass Change: No significant differences in skeletal muscle mass changes were detected between any pair of groups (all $P > 0.05$).

3.3. Analysis of Factors Influencing the Fat-Loss Effect in the Study Population

Linear regression analyses identified significant predictors of changes in body fat percentage (BFR) following the intervention (Table 4, Figure 1 and Figure 2).

Variables	β (95% CI)	S.E	t	P
Groups				
Control group	0.00 (Reference)			
Dietary intervention group	-1.07 (-1.98 - -0.15)	0.47	-2.28	0.024
Exercise intervention group	-0.45(-1.38 - 0.47)	0.47	-0.96	0.341
Joint intervention group	-2.33 (-3.26 - -1.40)	0.48	-4.91	<0.001
Sex				
Man	0.00 (Reference)			
Woman	0.46 (-0.44 - 1.36)	0.46	1.00	0.319
Age	-0.46 (-0.78 - -0.14)	0.16	-2.82	0.006
Height	-0.02 (-0.08 - 0.03)	0.03	-0.81	0.421
Weight	-0.03 (-0.05 - -0.01)	0.01	-2.13	0.035
BMI	-0.10 (-0.19 - -0.01)	0.05	-2.22	0.028
Body Fat	-0.08 (-0.12 - -0.03)	0.02	-3.05	0.003
WHR	-15.13 (-22.34 - -7.92)	3.68	-4.11	<0.001
Striated Muscle	-0.05 (-0.12 - 0.03)	0.04	-1.21	0.229

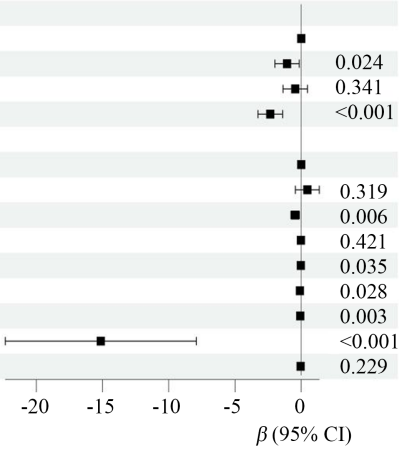

Figure 1. Forest plot for single-factor analysis.

Table 4. Linear regression analysis of factors affecting changes in body fat percentage of subjects.

Variables	one-factor					multifactor				
	β	S. E	t	P	β (95% CI)	β	S. E	t	P	β (95% CI)
Groups										
Control Group					0.00 (Reference)					0.0 (Reference)
Joint Intervention Group	−2.33	0.48	−4.91	<0.001	−2.33 (−3.26 - −1.40)	−2.18	0.45	−4.86	<0.001	−2.18 (−3.06 - −1.30)
Dietary Intervention Group	−1.07	0.47	−2.28	0.024	−1.07 (−1.98 - −0.15)	−1.13	0.44	−2.55	0.012	−1.13 (−2.00 - −0.26)
Exercise Intervention Group	−0.45	0.47	−0.96	0.341	−0.45 (−1.38 - 0.47)	−0.45	0.44	−1.00	0.317	−0.45 (−1.32 - 0.42)
Sex										
Man					0.00 (Reference)					
Woman	0.46	0.46	1.00	0.319	0.46 (−0.44 - 1.36)					
Age	−0.46	0.16	−2.82	0.006	−0.46 (−0.78 - −0.14)	−0.33	0.16	−2.09	0.039	−0.33 (−0.63 - −0.02)
Height	−0.02	0.03	−0.81	0.421	−0.02 (−0.08 - 0.03)					
Weight1	−0.03	0.01	−2.13	0.035	−0.03 (−0.05 - −0.01)	0.02	0.03	0.59	0.553	0.02 (−0.04 - 0.08)
BMI1	−0.10	0.05	−2.22	0.028	−0.10 (−0.19 - −0.01)	0.21	0.13	1.59	0.113	0.21 (−0.05 - 0.46)
BodyFat1	−0.08	0.02	−3.05	0.003	−0.08 (−0.12 - −0.03)	−0.13	0.06	−2.08	0.040	−0.13 (−0.26 - −0.01)
WHR1	−15.13	3.68	−4.11	<0.001	−15.13 (−22.34 - −7.92)	−12.82	5.33	−2.41	0.018	−12.82 (−23.26 - −2.37)
StriatedMuscle1	−0.05	0.04	−1.21	0.229	−0.05 (−0.12 - 0.03)					

Variables	β (95% CI)	S.E	t	*P*
Intercept	14.19 (5.76 - 22.62)	4.30	3.30	0.001
Groups				
Control group	0.00 (Reference)			
Dietary intervention group	-1.13 (-2.00 - -0.26)	0.44	-2.55	0.012
Exercise intervention group	-0.45 (-1.32 - 0.42)	0.44	-1.00	0.317
Joint intervention group	-2.18 (-3.06 - -1.30)	0.45	-4.86	<0.001
Age	-0.33 (-0.63 - -0.02)	0.16	-2.09	0.039
Weight	0.02 (-0.04 - 0.08)	0.03	0.59	0.553
BMI	0.21 (-0.05 - 0.46)	0.13	1.59	0.113
Body Fat	-0.13 (-0.26 - -0.01)	0.06	-2.08	0.040
WHR	-12.82 (-23.26 - -2.37)	5.33	-2.41	0.018

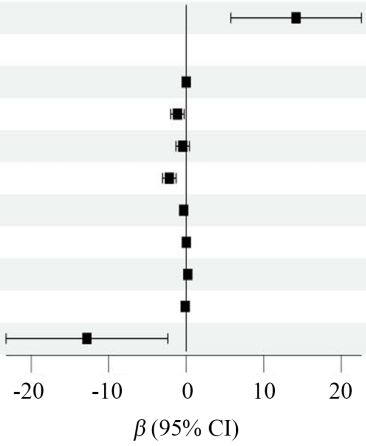

Figure 2. Multi-factor analysis forest map.

3.3.1. Univariate Analysis

Significant predictors of greater BFR reduction included: Intervention groups (vs. Control): Joint Intervention ($\beta = -2.33\%$, 95% CI: −3.26 to −1.40, $P < 0.001$), Dietary Intervention ($\beta = -1.07\%$, 95% CI: −1.98 to −0.15, $P = 0.024$). Sex: Females showed greater reduction than males ($\beta = -0.46\%$, 95% CI: −0.78 to −0.14, $P = 0.006$). Baseline adiposity: Higher baseline weight ($\beta = -0.03\%$/kg, 95% CI: −0.05 to −0.01, $P = 0.035$), Higher baseline BMI ($\beta = -0.10\%/kg/m^2$, 95% CI: −0.19 to −0.01, $P = 0.028$), Higher baseline body fat ($\beta = -0.08\%$/kg, 95% CI: −0.12 to −0.03, $P = 0.003$), Higher baseline WHR ($\beta = -15.13\%$/unit, 95% CI: −22.34 to −7.92, $P < 0.001$). Age, height, and baseline skeletal muscle mass were non-significant predictors.

3.3.2. Multivariate Analysis

After adjustment for covariates, independent predictors of BFR were: Intervention effects (vs. Control): Joint Intervention: $\beta = -2.18\%$ (95% CI: −3.06 to −1.30, $P < 0.001$). Dietary Intervention: $\beta = -1.13\%$ (95% CI: −2.00 to −0.26, $P = 0.012$). Exercise Intervention: Non-significant ($\beta = -0.45\%$, 95% CI: −1.32 to 0.42, $P = 0.317$). Sex: Females achieved greater reductions ($\beta = -0.33\%$, 95% CI: −0.63 to −0.02, $P = 0.039$). Baseline adiposity: Higher baseline body fat ($\beta = -0.13\%$/kg, 95% CI: −0.26 to −0.01, $P = 0.040$). Higher baseline WHR ($\beta = -12.82\%$/unit, 95% CI: −23.26 to −2.37, $P = 0.018$). Baseline weight and BMI became non-significant in the adjusted model.

4. Discussion

With the rapid development of society, obesity has become an increasingly serious public health problem. According to a recent study published by The Lancet [14], the global obese population will reach more than 1 billion in 2022. BMI, as a commonly used indicator for evaluating obesity, may categorize individuals with high body fat percentage but normal body weight (18.5 - 23.9 kg/m^2) as "non-obese", resulting in missed opportunities to prevent or treat excess body fat and related

complications [15]. This results in missed opportunities to prevent or treat excess body fat and related complications [15]. In this context, body fat percentage may be a more appropriate indicator for the evaluation of obesity [16], as it is associated with metabolic dysregulation regardless of body weight [17]. Nowadays, the problem of overweight and obesity among college students is becoming more and more serious, which has aroused widespread concern in society; but most of the existing studies still define overweight and obesity by BMI, and the present study adopts body fat percentage as an indicator to measure obesity, and recruits college students with overweight and obesity, and conducts online behavioral interventions for them for a period of 6 weeks, and the results found that the online dietary and exercise interventions can significantly reduce body fat mass and body fat percentage.

This study intervened with current college students; most previous studies have chosen to intervene with high-risk populations such as bariatric clinic patients and less often with college student populations. Compared with other populations, this group is relatively homogeneous in terms of age and educational background, which helps to control variables and improve the internal validity of the experimental results; college students have a higher level of education and cognitive ability than the general population, which makes it easier for them to understand complex research requirements and processes, thus enhancing the validity and reliability of the data [18]; in addition, most college students have a high level of familiarity with technology (e.g., computers, Internet), which facilitates the conduct of online surveys. Therefore, selecting this population for the intervention may yield better results.

Previous studies have found that Internet-based online interventions can have beneficial effects for a variety of conditions, such as controlling blood glucose, lowering blood pressure, and reducing body weight [7] [19] [20]. Promoting healthy behaviors (e.g., physical activity and healthy eating) through lifestyle interventions has been recommended as a first-line treatment for obese patients and may be an effective tool for treating obesity and preventing obesity-related health burdens [21]. In this study, an online diet and/or exercise intervention was conducted through the creation of a WeChat group chat in which subjects clocked in their diet and/or exercise daily, and the researchers provided feedback and timely corrections of irrational behaviors; subjects could also communicate with the researchers in the WeChat group if they had any doubts during the trial. This Internet-based intervention can provide immediate, easily accessible, relatively affordable, and personalized support for self-management and promote behavioral change in a large portion of the population [22].

The results of this study found that, after 6 weeks of online intervention, online dietary intervention and online exercise intervention resulted in a significant decrease in BMI, a significant decrease in body fat mass in the exercise group and dietary exercise group, a significant decrease in body fat percentage after dietary intervention and/or exercise intervention, and a significant increase in skeletal

muscle mass in the dietary exercise group. The results illustrate the effectiveness of the Internet application for fat loss and are consistent with the results of previous studies [6] [23]. It is well known that weight loss interventions lead to the loss of fat-free mass and muscle mass [24]. Maintaining fat-free mass during weight loss is an important goal because, in addition to high fat mass [9], low fat-free mass is associated with high mortality [25] and plays an important role in energy expenditure [26]. In addition, this study found that an important factor influencing the effectiveness of fat loss was BMI, which is also consistent with the results of previous studies [27]. The reason for this may be, on the one hand, that people with higher BMI have a relatively higher body fat content, so the relative amount of fat that can be reduced is greater; on the other hand, it may be because the compliance of people with higher BMI is relatively good. Compliance is an important influence on the effect of weight loss, and some studies have shown that, compared with the overweight body type, the obese body type is a favorable factor for weight loss compliance [28].

In terms of program participation, the high percentage of subjects completing the entire program (134/140, 95.7%) is similar to levels reported in previous e-interventions [23]. In this study, a dietitian was spoken to, and nutritional advice was given to the individuals after body composition was measured; during the intervention, the researchers also shared health information and answered the study subjects' queries in a WeChat group chat. It has been found that increasing knowledge about healthy lifestyles and having a tailored intervention plan can enhance subjects' adherence to the intervention [29]. In this sense, the widespread and continuously growing access and use of the Internet has become a major resource for assessing health information [30]. The Internet is an effective way of preventing and treating chronic diseases through the promotion of healthy lifestyles, as it allows access to a larger number of individuals (including those with limited access to health services or low levels of social support) and potentially provides a deeper connection at a lower cost than traditional face-to-face programs [31] [32]. The use of modern information and communication technologies (ICTs) to deliver physical activity and dietary interventions is promising, given their increasing availability in many developing countries.

This study has some limitations. First, although the results of this study show that Internet-based online interventions have achieved good results, the effectiveness of web-based interventions is still under debate [33], especially its long-term effects need to be further investigated, and longer-term observations are needed to verify its long-term effects; second, the study area is more limited, only a survey of college students in a school in the Luoyang area, and extrapolation of the conclusions requires that the conclusions be extrapolated cautiously. Third, the gender distribution of the sample was uneven, and the overall effect observed may reflect the response of the female group more, while the difference in the participation or effect of the online intervention among males needs to be further verified. Future studies need to increase the follow-up period, expand the study area,

equalize the gender ratio of the sample, and increase the indicators for data collection to better control confounding factors.

In summary, Internet-based dietary and/or exercise interventions can effectively reduce body fat mass and body fat percentage in college students with excessive body fat percentage, and this online intervention mode is immediate, convenient, and not limited by time and space, which makes it suitable for promotion among the obese population.

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Authors' Contributions

Wang Wenjing: Writing-original draft, design questionnaire, funding. Tang Lulu: Writing-original draft. Chang Qi: Guided experimental and research work. Liu Xin and Huang Mei: Completing the on-site questionnaire. Zhao Xiang and Lu Shanshan: Methodology, investigation, data curation.

Conflicts of Interest

All authors declare that they have no conflicts of interest.

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