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ORIGINAL ARTICLE

Effects of monthly feedback of VFA measured by dual BIA method in Japanese patients with obesity: a randomized controlled study

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Summary

Objective

To investigate the effects of monthly feedback of changes in visceral fat area (VFA) as measured by dual bioelectrical impedance analysis method and the importance of VFA in individuals with obesity.

Methods

Thirty-eight Japanese patients with obesity underwent VFA measurements. The feedback group was given feedback on VFA measurements each month for 4 months. The control group underwent VFA measurements at the beginning and end of the study but was not informed of the results. All the study participants completed eating behaviour and weight efficacy lifestyle questionnaires.

Results

Mean age was 53.9 (14.3) years; mean body mass index was 30.6 (4.3) kg m^{-2}. At the 4-month follow-up, there was no significant difference in VFA reduction between the control and feedback groups (−4.4% vs. −3.0%; 95% CI, −3.8 to 5.5). In post-hoc analysis using the overall group irrespective of allocation, changes of eating style were significantly associated with a reduction in VFA at 4 months ($p = 0.034$).

Conclusions

Monthly feedback on changes in VFA does not reduce VFA. More frequent feedback may be required. In post-hoc analysis, changes of eating style were associated with a reduction in VFA.

Keywords: Dual bioelectrical impedance analysis, eating behaviour, obesity, visceral fat.

Introduction

Abdominal visceral fat accumulation is associated with metabolic abnormalities in obesity-related diseases (1–7). Visceral fat area (VFA) is used as a clinical parameter of abdominal adiposity (1,4,8). Unlike body mass index (BMI) and waist circumference (WC), VFA measures adipose tissue without muscle, bone or other irrelevant structures; therefore, VFA is a more direct indicator of obesity (6). Previously, there were no precise methods for the measurement of intra-abdominal and subcutaneous fat accumulation besides computed tomography (CT) (9) or magnetic resonance imaging (10). Although CT at umbilical level is the gold standard for the evaluation of VFA, this method is costly and needs large apparatus; additionally, radiation exposure cannot be avoided. Accordingly, CT cannot be performed frequently because of radiation and cost. Magnetic resonance zimaging also has problems of cost and needs large apparatus. However, we have recently developed a dual bioelectrical impedance analysis (dual BIA) instrument that can be used to evaluate abdominal adiposity in the routine clinical care of patients with obesity (11–15). We have also reported that the dual BIA instrument could detect the weekly change of dual BIA-VFA under calorie restriction in patients with obesity and demonstrated a substantially larger change in VFA compared with changes of body weight and WC in early

weeks (12). Other study demonstrated a good correlation between VFA measured by this dual BIA instrument and that measured by an abdominal CT (16).

Body-weight feedback provides an opportunity for patients to notice how specific situations, eating patterns and physical activities are associated with changes in body-weight reduction (17). Although previous studies had reported that this feedback improved weight control (18–20), no studies to date have specifically reported the effects of feedback about VFA changes on subsequent VFA reductions. Here, we conducted a randomized controlled study of the effects of feedback of changes in VFA on subsequent VFA reduction. The purpose of this study was to explore the effect of feedback on VFA, measured by dual BIA, and weight loss in individuals with obesity.

The Oita University questionnaire of eating behaviours and the weight efficacy lifestyle (WEL) questionnaire are commonly used measures of behaviours and self-efficacy of eating. Since the associations of eating behaviours using the Oita University questionnaire (21,22) and of eating self-efficacy using the weight efficacy lifestyle (WEL) questionnaire (23–29) have been reported to be significant with BMI reduction, eating behaviours and eating self-efficacy on VFA reduction were examined in the present study about VFA reduction.

Materials and methods

Study design

A randomized controlled study with a health intervention was conducted, with the data collected at baseline and during the subsequent 4 months. The protocol for this study was approved by the medical ethics review boards of Kyoto University Hospital (No. E1747) and was compliant with the Helsinki Declaration. Written informed consent was obtained from all participants.

Participant recruitment and eligibility criteria

Using outpatients at the division of Endocrinology and Metabolism of Kyoto University Hospital (Kyoto, Japan) and at the division of Obesity of Horii Internal Medicine Clinic (Kyoto, Japan), recruitment was conducted consecutively between July 2013 and October 2013. Participants were Japanese patients who were obese and who had presented to an outpatient clinic for weight reduction. Patients were considered eligible if they were had a BMI of >25 kg m^{-2}, which is the definition of obesity in the Guideline For Obesity issued by the Japan Society for the Study of Obesity (22); were aged between 20 and 80 years; and were able to perform activities of daily living. Patients were excluded if they were receiving a glucagon-like peptide-1 analogy, had a disease such as Cushing's syndrome and hypothyroidism, had difficulty participating in the study because of impaired comprehension or an unstable mental state, had a serious illness that an attending physician thought would affect survey items, were participating in other intervention research program at the time of registration or were deemed ineligible by their attending physician for other reasons.

Randomization

When consent forms were received, participants were registered. The researcher reported age and sex of participants by e-mail to the study coordinator at the university who was independent from data collection and analysis. The study coordinator then used computer random generated numbers with a minimization method to allocate registered participants to the control or feedback group with age and sex adjusted.

Usual medical care for both groups

The intervention duration was 4 months. During the study, the participants attended their usual outpatient visits each month with body weight, blood pressure and blood biochemical and urine assessments. Participants were also requested to maintain daily body weight and dietary intake records, which their physicians then used to advise them regarding lifestyle modifications during the monthly outpatient visits. All patients were instructed to maintain the same levels of energy intake and physical activity for the entire period, as recommended by the Japan Atherosclerosis Society's Guidelines for the Diagnosis and Treatment of Atherosclerotic Cardiovascular Diseases (16). Accordingly, the diet therapy comprised 25 kcal kg^{-1} of ideal body weight per day and patients were instructed to exercise for at least 30 min at a moderate intensity at least 3 d week^{-1}. Medication was not changed during the period. No anti-obesity drugs or obesity surgery was prescribed. Dieticians provided nutritional guidance at each monthly outpatient visit.

Visceral fat area (VFA) measured by dual bioelectrical impedance analysis (dual BIA)

The participants' VFA was determined by using a dual BIA-based DUALSCAN (Omron Healthcare Co., Ltd., Kyoto, Japan). The principle behind this determination has previously been described in detail by the manufacturer and our group (11–15). For the feedback group,

VFA measurements were performed at each visit with explanations of the results of VFA and the importance of VFA in metabolic abnormalities at the same time. The control group had VFA measurements at baseline and 4 months later. The results of VFA at baseline and 4 months later were informed with the control group after the measurement at 4 months later.

Oita University eating behaviour questionnaire

Eating behaviour of both groups was assessed by using the Oita University questionnaire at every visit from baseline to 4 months (21,22). This questionnaire is a 55-item self-rated questionnaire with seven categories. All items were rated on a four-point scale from 1 for 'No, it is not so' to 4 for 'Yes, exactly so.' Responses to each question were added together for the seven categories with higher scores indicating disordered eating behaviour that predisposed the participants to weight increase (for details, see the Supporting Information). This questionnaire produces different scores for men and women because a different scoring table is used for each sex. To eliminate the effect of sex during comparisons between the two groups, scores were corrected to a percentage of the total score (21).

Weight efficacy lifestyle (WEL) questionnaire

Eating self-efficacy was assessed in both groups by using the WEL questionnaire (23,24) at baseline and each month for 4 months. This 20-item questionnaire consists of five situational domains, and participants were required to rate their confidence in resisting their desire to eat on a 0-point (not confident) to 9-point (very confident) Likert scale. This questionnaire was translated to Japanese language. Responses are summed to form a total score, with higher scores reflecting greater confidence (for details, see the Supporting Information).

Visual analogy scale questionnaire for measuring subjective feelings about reducing VFA

Both groups were requested to provide their subjective feelings about any VFA reduction on a visual analogy scale (VAS) at baseline and at each visit for the next 4 months of the study. We evaluated three items by using VAS: confidence, sense of fulfilment and interest. All VASs were measured by hand, from left (minimum score of 0 mm) to right (maximum score of 100 mm); higher scores indicated stronger subjective feelings about VFA reduction (for details, see the Supporting Information).

Statistical analyses

The changes of anthropometry, including those in VFA in the control and feedback groups, from baseline to the end of the study were compared by using paired *t*-test. Anthropometry including VFA, the eating behaviour questionnaire, the WEL questionnaire and VAS scores baseline and 4 months later were compared between the control and feedback groups by using analyses of covariance with several allocation adjustment variables (age and sex) added as covariates. Furthermore, in a post-hoc analysis, multivariate analyses were also performed for the overall group to examine which factors among the changes in eating behaviours and the WEL and VAS scores influenced changes in VFA from baseline to the end of the study. Moreover, analyses of variance were performed to compare changes in VFA, eating behaviours and WEL and VAS scores between the group that had a decrease in VFA and the group that had an increase in VFA from baseline to the end of the study. All analyses were conducted by using JMP (version 12.0) software (SAS Institute Inc., Cary, NC), and the level of significance was set at $p < 0.05$.

Results

Study profile and baseline characteristics

Between July 2013 and October 2013, 47 patients who met the eligibility criteria were recruited. And then 45 patients were enrolled in the study and randomly allocated to the control group (n = 23) or feedback group (n = 22). Between December 2013 and Jun 2014, 21 participants in the control group and 17 participants in the feedback group completed the 4-month protocol and were included in the analyses (Figure 1). Table 1A shows baseline characteristics. Table 1B summarizes characteristics in eating behaviour, WEL and subjective feelings at baseline.

Visceral fat area (VFA) measured by dual bioelectrical impedance analysis (dual BIA): control group and feedback group

The change (%) in VFA of all the study participants was −3.8 (14.4). The changes in VFA of the control group and of the feedback group from baseline to the end of the study were not significant (−7.0 [4.0] [95% CI, −14.2 to 0.1]) and (−3.4 [0.4] [95% CI, −12.7 to 5.9]), respectively (Table 2). There was no significant difference in the changes in VFA (%) from baseline to the end of the study between the control and feedback groups (−4.4

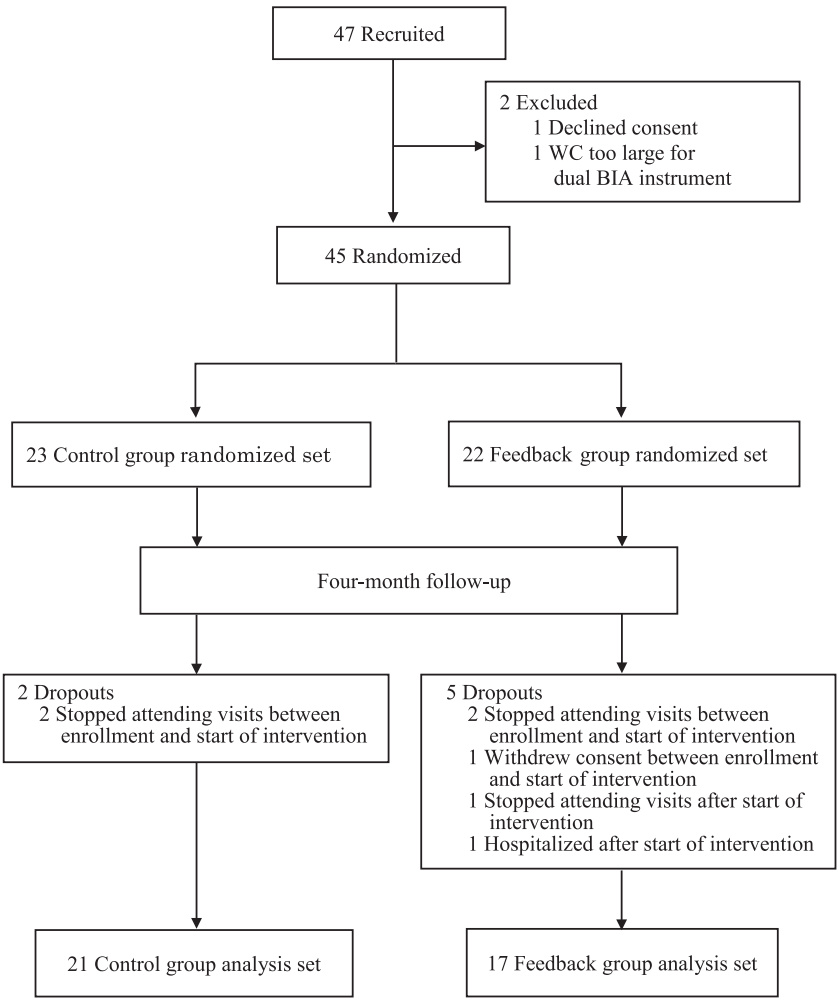

Figure 1 Forty-five participants were enrolled in the study and randomly allocated to the control group (n = 23) or the feedback group (n = 22). Twenty-one participants in the control group and 17 participants in the feedback group completed the 4-month protocol and were included in analyses (n = 38).

Table 1A Baseline characteristics

Variables	All n = 38	Control n = 21	Feedback n = 17
Male/Female	18/20	10/11	9/8
Age, years	53.9 (14.3)	55.4 (13.6)	52.1 (15.3)
Weight, kg	81.8 (16.3)	81.5 (13.2)	82.3 (19.9)
BMI, kg m^{-2}	30.6 (4.3)	30.9 (4.0)	30.2 (4.7)
Waist circumference, cm	104.4 (10.4)	105.6 (10.2)	102.9 (10.9)
VFA, cm^2	127.1 (40.0)	133.7 (42.1)	119.0 (36.8)
Type 2 diabetes (%)	21 (56.8)	12 (57.1)	9 (52.9)
Dyslipidemia (%)	23 (62.2)	10 (47.6)	13 (76.5)
Hypertension (%)	21 (56.8)	11 (52.4)	10 (58.8)
Hyperuricemia (%)	6 (16.2)	4 (19.0)	2 (11.8)
Medication (%)	32 (86.5)	16 (76.2)	16 (94.1)

BMI, body mass index; VFA, visceral fat area.

[12.6] vs. −3.0 [16.8]; 95% CI, −3.8 to 5.5). The changes of BMI of the control group and of the feedback group from baseline to the end of the study were not significant (−0.1 [1.3] [95%CI, −0.7 to 0.5]) and (0.04 [1.5] [95% CI, −0.7 to 0.8]), respectively. There was no significant difference in BMI changes (%) from baseline to the end of the study between the control and feedback groups (−0.3 [4.6] vs. 0.04 [4.8]; 95% CI, −1.7 to 1.2). The changes of WC of the control group from baseline to the end of the study were not significant (−1.0 [15.6] [95% CI, −2.8 to 0.9]) while those of the feedback group were significant (−2.3 [18.1] [95% CI, −4.3 to −0.2]). There was no significant difference in WC changes (%) from baseline to the end of the study between the control and feedback groups (−0.9 [4.0] vs. −2.2 [4.1]; 95% CI, −1.8 to 0.7).

Table 1B Baseline characteristics in eating behaviour, WEL and subjective feelings

Variables	All *n* = 38	Control *n* = 21	Feedback *n* = 17
Eating behaviour[†1]			
Recognition of weight and constitutional predisposition	64.5 (13.6)	65.1 (12.3)	63.8 (15.5)
Motivation to eat	57.2 (14.8)	56.4 (17.0)	58.1 (12.0)
Eating as diversion	50.2 (17.9)	47.9 (18.5)	52.9 (17.4)
Feeling of hunger/satiation	56.7 (16.7)	55.2 (17.6)	58.6 (16.0)
Eating style	65.1 (17.2)	62.1 (19.3)	68.8 (13.8)
Food preferences	54.1 (15.2)	51.9 (16.8)	56.8 (12.9)
Regularity of eating habits	57.7 (13.4)	54.6 (13.6)	61.6 (12.5)
WEL[†2]			
Negative emotions	18.5 (9.2)	20.4 (9.7)	16.1 (8.1)
Availability	16.1 (8.0)	17.1 (9.5)	14.7 (5.8)
Social pressure	16.8 (8.3)	18.2 (9.2)	15.1 (7.0)
Physical discomfort	23.5 (7.9)	25.5 (8.4)	21.0 (6.6)
Positive activities	23.3 (7.7)	25.1 (7.8)	21.1 (7.2)
Subjective feelings in VAS[†3]			
Confidence	52.2 (23.3)	54.9 (21.7)	48.9 (25.4)
Sense of fulfilment	40.8 (28.2)	39.7 (26.5)	42.1 (30.9)
Interest	81.5 (18.4)	84.0 (15.8)	78.5 (21.2)

[†1]Higher scores indicated disordered eating behavior predisposing to weight gain.
[†2]Higher scores indicated higher self-efficacy of eating.
[†3]Higher scores indicated stronger subjective feelings about reducing VFA.
WEL, weight efficacy lifestyle; VAS, visual analogy scale.

Table 2 Changes in the anthropometry of the randomized groups

Variables	All *n* = 38	Control *n* = 21	Feedback *n* = 17	Analysis of covariance* (Feedback–Control)	
				Estimated difference	95% CI
Weight, kg					
Baseline	81.8 (16.3)	81.5 (13.2)	82.3 (19.9)		
4 months	81.7 (16.5)	81.2 (13.6)	82.3 (19.9)		
Change	−0.2 (4.0)	−0.3 (3.8)	−0.02 (4.2)		
95% CI[†]	−1.5, 1.1	−2.0, 1.5	−2.2, 2.1		
Change (%)	−0.1 (4.6)	−0.3 (4.6)	0.04 (4.8)	0.25	−1.2, 1.7
BMI, kg m^{-2}					
Baseline	30.6 (4.3)	30.9 (4.0)	30.2 (4.7)		
4 months	30.6 (4.6)	30.9 (4.3)	30.2 (5.2)		
Change	−0.02 (1.4)	−0.1 (1.3)	0.04 (1.5)		
95% CI[†]	−0.5, 0.4	−0.7, 0.5	−0.7, 0.8		
Change (%)	−0.1 (4.6)	−0.3 (4.6)	0.04 (4.8)	0.25	−1.7, 1.2
Waist, cm					
Baseline	104.4 (10.4)	105.6 (10.2)	102.9 (10.9)		
4 months	102.8 (11.1)	104.6 (10.5)	100.6 (11.6)		
Change	−1.6 (16.6)	−1.0 (15.6)	−2.3 (18.1)		
95% CI[†]	−2.9, −0.2	−2.8, 0.9	−4.3, −0.2		
Change (%)	−1.5 (4.0)	−0.9 (4.0)	−2.2 (4.1)	−0.58	−1.8, 0.7
VFA, cm^2					
Baseline	127.1 (40.0)	133.7 (42.1)	119.0 (36.8)		
4 months	121.7 (38.9)	126.6 (38.5)	115.6 (39.8)		
Change	−5.4 (4.0)	−7.0 (4.0)	−3.4 (0.4)		
95% CI[†]	−10.9, 0.04	−14.2, 0.1	−12.7, 5.9		
Change (%)	−3.8 (14.4)	−4.4 (12.6)	−3.0 (16.8)	0.84	−3.8, 5.5

*Analysis of covariance with allocation adjustment variables (age, sex) added as covariates, comparisons between the control group and the feedback group.
[†]Comparisons between baseline and after 4 months using paired *t*-test.
BMI, body mass index; VFA, visceral fat area.

Questionnaire results at baseline and 4 months: control group and feedback group

Any changes on the eating behaviour questionnaire from baseline to the end of the study were compared between the control and feedback groups. The feeling of hunger/satiation was significantly improved in the control group compared with the feedback group (−5.2 vs. 2.9; 95% CI, 0.9 to 7.6) (Table 3). No other significant differences were observed in any of the other eating behaviour questionnaire items between the two groups. Changes in eating self-efficacy using WEL and the subjective feelings about reducing VFA using the VAS were also compared between the control and feedback groups. However, there were no significant differences in any WEL items or the VAS scores between the two groups (see Table S1 in the Supporting Information). The reason for any improvement in hunger/satiation on the eating behaviour questionnaire in the control group was unclear.

Post-hoc analyses of all study participants

From baseline until the end of the study, there was no significant difference in the change in VFA between the control and feedback groups. Therefore, as a post-hoc analysis, we assessed which factors were associated with changes in VFA in the entire group using a single regression analysis for changes in the eating behaviour questionnaire, eating self-efficacy using the WEL and subjective feelings about reducing VFA using the VAS. Changes in VFA were associated with changes in eating style on the eating behaviour questionnaire (Table 4). Furthermore, changes in VFA were associated with changes in social pressure on the WEL questionnaire. Changes in VFA also tended to be associated with changes in food availability on the WEL questionnaire, changes in confidence on VAS and changes in the sense of fulfilment on the VAS.

Then, the five items found to be associated (eating style on the eating behaviour questionnaire and social pressure

Table 3 Changes in scores of eating behaviour of randomized groups

Variables	All *n* = 38	Control *n* = 21	Feedback *n* = 17	Analysis of covariance* (Feedback–Control)	
				Estimated difference	95% CI
Eating behaviour					
Recognition of weight and constitutional predisposition					
Baseline	64.5 (13.6)	65.1 (12.3)	63.8 (15.5)		
4 months	63.7 (12.1)	64.5 (11.0)	62.7 (13.1)		
Change in scores	−0.8 (13.2)	−0.5 (13.4)	−1.1 (13.2)	−0.14	−4.5, 4.2
Motivation to eat					
Baseline	57.2 (14.8)	56.4 (17.0)	58.1 (12.0)		
4 months	55.8 (16.5)	55.3 (18.2)	56.5 (14.9)		
Change in scores	−1.4 (11.8)	−1.1 (13.1)	−1.7 (10.4)	−0.29	−4.2, 3.6
Eating as diversion					
Baseline	50.2 (17.9)	47.9 (18.5)	52.9 (17.4)		
4 months	48.7 (14.9)	46.4 (15.8)	51.5 (13.7)		
Change in scores	−1.2 (16.1)	−1.5 (16.4)	−1.5 (16.2)	−0.08	−5.3, 5.2
Feeling of hunger/satiation					
Baseline	56.7 (16.7)	55.2 (17.6)	58.6 (16.0)		
4 months	55.2 (17.0)	50.0 (15.7)	61.5 (16.9)		
Change in scores	−1.5 (11.4)	−5.2 (10.8)	2.9 (10.7)	4.25	0.9, 7.6
Eating style					
Baseline	65.1 (17.2)	62.1 (19.3)	68.8 (13.8)		
4 months	63.6 (17.7)	58.6 (17.6)	69.7 (16.4)		
Change in scores	−1.6 (12.4)	−3.6 (12.8)	0.9 (11.9)	2.29	−1.7, 6.3
Food preferences					
Baseline	54.1 (15.2)	51.9 (16.8)	56.8 (12.9)		
4 months	52.7 (16.4)	50.1 (17.1)	56.0 (15.4)		
Change in scores	−1.4 (10.4)	−1.8 (12.0)	−0.9 (8.5)	0.38	−3.1, 3.8
Regularity of eating habits					
Baseline	57.7 (13.4)	54.6 (13.6)	61.6 (12.5)		
4 months	55.8 (13.3)	52.7 (13.3)	59.6 (12.8)		
Change in scores	−2.0 (9.8)	−1.9 (10.6)	−2.0 (8.9)	0.01	−3.2, 3.3

*Analysis of covariance with allocation adjustment variables (age, sex) added as covariates, comparisons between the control group and the feedback group.

Table 4 Regression analysis of changes in VFA and changes in eating behaviour, WEL and subjective feelings of all participants

All n = 38	Model 1*[1]			Model 2*[2]		
	Estimated slope	SE	P value	Estimated slope	SE	P value
Eating behaviour						
Recognition of weight and constitutional predisposition	0.28	0.18	0.121			
Motivation to eat	0.14	0.21	0.505			
Eating as diversion	0.01	0.15	0.950			
Feeling of hunger/satiation	0.36	0.22	0.116			
Eating style	0.52	0.18	0.007*	0.44	0.20	0.034*
Food preferences	0.10	0.23	0.670			
Regularity of eating habits	0.18	0.24	0.462			
WEL						
Negative emotions	−0.29	0.34	0.392			
Availability	−0.61	0.31	0.057	−0.12	0.47	0.801
Social pressure	−0.71	0.32	0.033*	−0.42	0.47	0.381
Physical discomfort	−0.22	0.29	0.440			
Positive activities	−0.17	0.31	0.598			
Subjective feelings in VAS						
Confidence	−0.13	0.07	0.058	−0.03	0.08	0.677
Sense of fulfilment	−0.14	0.07	0.060	−0.01	0.09	0.868
Interest	−0.14	0.10	0.168			

*[1]Model 1 is a single regression analysis adjusted for the effect of allocation.
*[2]Model 2 is a multivariate analysis is including all variables that had a P value of < 0.1 in Model 1.
*$P < 0.05$.
WEL, weight efficacy lifestyle; VAS, visual analogy scale.

on the WEL) or that had a tendency to be associated (food availability on WEL and confidence and sense of fulfilment on VAS) with changes in VFA in the single regression analysis were subjected to a multivariate analysis. This analysis revealed that only changes in eating style on the eating behaviour questionnaire were associated with changes in VFA (multivariate analyses, p = 0.034) (Table 4).

Further analysis in VFA decrease group and VFA increase group

We then evaluated changes in VFA not only as a continuous variable but also a categorical variable. The participants were divided into a VFA decrease group (n = 24) or a VFA increase group (n = 14) based on changes in VFA after the 4 months of the study, and the two groups were further examined. At the end of the study, the total scores for eating style on the eating behaviour questionnaire in the VFA decrease group had significantly improved more than those in the VFA increase group (−4.6 [11.4] vs. 3.6 [12.8]; p = 0.049) (Table 5).

A significant difference in the changes of the total scores for availability on the WEL was observed between the VFA decrease group and the VFA increase group; the total scores for availability on WEL in the VFA decrease group were significantly better than those in the VFA increase group (4.2 [6.9] vs. −1.5 [7.3]; p = 0.022) (Table 5).

The score for confidence on VAS was significantly higher in the VFA decrease group than in the VFA increase group at the end of the study (9.1 [29.2] vs. −19.3 [37.1]; p = 0.013). The sense of fulfilment on the VAS also significantly increased in the VFA decrease group compared with the VFA increase group (9.4 [31.7] vs. −14.1 [28.8]; p = 0.028) (Table 5).

Discussion

The major objective of this study is to investigate the effects of feedback on changes in VFA as measured by dual BIA in participants with obesity. Previous study by the calorie restriction demonstrates that the average reduction in dual BIA-VFA during the 3 weeks was 18.9%, which was larger than in weight (5.3%) and WC (3.8%) (12), suggesting that the change in VFA is more clearly understandable than the change in weight. Therefore, we had hypothesized that feedback about any changes in VFA would result in successful subsequent VFA reduction. However, there was no significant difference in the change in VFA over this time frame between the control and feedback groups. There may be several reasons which could explain the lack of a significant difference. During the study duration, along

Table 5 Changes in scores for eating behaviour, WEL and subjective feelings between the VFA decrease and increase groups

Variables	VFA decrease $n = 24$	VFA increase $n = 14$	ANOVA P value
Eating behaviour			
Recognition of weight and constitutional predisposition	−3.8 (12.5)	4.0 (13.4)	0.089
Motivation to eat	−1.6 (12.9)	−1.0 (10.2)	0.892
Eating as diversion	−1.3 (17.5)	−1.8 (14.0)	0.937
Feeling of hunger/satiation	−1.7 (13.2)	−1.3 (7.7)	0.937
Eating style	−4.6 (11.4)	3.6 (12.8)	0.049*
Food preferences	−1.4 (12.5)	−1.3 (5.5)	0.980
Regularity of eating habits	−2.7 (10.0)	−0.6 (9.6)	0.537
WEL			
Negative emotions	0.6 (7.2)	0.8 (7.4)	0.935
Availability	4.2 (6.9)	−1.5 (7.3)	0.022*
Social pressure	1.8 (8.2)	−2.1 (4.7)	0.110
Physical discomfort	−1.0 (8.7)	0.4 (8.2)	0.630
Positive activities	−1.2 (7.7)	−0.1 (8.1)	0.682
Subjective feelings in VAS			
Confidence	9.1 (29.2)	−19.3 (37.1)	0.013*
Sense of fulfilment	9.4 (31.7)	−14.1 (28.8)	0.028*
Interest	−4.3 (26.7)	−12.3 (20.9)	0.343

*$P < 0.05$.
WEL, weight efficacy lifestyle; VAS, visual analogy scale.

with feedback on the changes in VFA, participants in both groups were examined by their physicians and received nutritional dietary guidance. Furthermore, the participants maintained daily records of body weight and dietary intake; thus, they received self-feedback as well as feedback from their physicians and dieticians. Therefore, any change in VFA may have been influenced not only by the feedback on VFA but also by the usual medical care described earlier. If the VFA measurement and feedback were performed more frequently like the body-weight measurements, the feedback of changes in VFA might influence subsequent changes in VFA.

Furthermore, we performed post-hoc analyses by using the overall group irrespective of allocation. In the multivariate analyses for the overall group to examine which factors among the changes in eating behaviours, and the WEL and VAS scores influenced changes in VFA, only changes in eating style on the eating behaviour questionnaire were associated with changes in VFA. This finding was compatible with the previous study reporting that increased chewing suppressed the food intake in one meal (30).

We also examined differences between VFA decrease group and VFA increase group. Compared with the VFA increase group, participants with decreased VFA showed an improved eating style in the eating behaviour questionnaire. This finding was consistent with the results for the multivariate analyses of the overall group, in which only changes in eating style on the eating behaviour questionnaire were significantly associated with changes in VFA. Dietary advice for patients with obesity may reduce VFA by focusing on an improvement in eating styles. Moreover, food availability on the WEL and confidence and sense of fulfilment on the VAS were better in the VFA decrease group than in the VFA increase group. Since the questionnaire at the end of the study was administered before the VFA measurements, the improvements in food availability on the WEL and in the confidence and sense of fulfilment on the VAS were not due to VFA feedback at 4 months but may be caused by an awareness of personal body-weight reductions from the daily body-weight measurements.

The present study demonstrated that the monthly feedback on measured VFA results did not significantly reduce VFA by itself. The post-hoc analysis of entire group indicated that the improvement of eating style may have contributed to VFA decrease. Dietary therapy for patients with obesity may reduce VFA by focusing on improvements in eating style.

This study has several limitations. The study was a small clinical study conducted in two hospitals, with a small study population and a short duration. The number of drop-outs was large in this small study. The clinical contribution of this study includes the exploration of the method of VFA measurement by dual BIA, which is a non-invasive and radiation-free method. Although the value of feedback on VFA in promoting weight loss was not significant in this study, further studies using VFA as a biomarker for follow-up of patients with obesity are recommended.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1. Changes in the scores of WEL and the subjective feelings in the randomized groups