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ORIGINAL CONTRIBUTION

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Body composition in bulimia nervosa patients compared to healthy females

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Summary *Objective* In contrast to anorexia nervosa there is a lack of research on body composition in bulimia nervosa patients. The aim of the study was to examine the body composition in underweight, normal-weight and overweight bulimia nervosa patients in comparison with healthy sedentary females, to assess the changes in body composition and subcutaneous fat after five months treatment, and to analyze the relation between body composition variables. *Design* The body composition of 138 female bulimia nervosa patients and 188 healthy sedentary females was studied using underwater weighing and skinfold measurements. *Results* A good agreement was found between the results obtained by underwater weighing and skinfold measurements. Normal-weight bulimics and control subjects did not differ significantly in body composition. In comparison with healthy controls, underweight and overweight bulimics showed a lower or higher percentage body fat, respectively. In underweight bulimics the fat mass increased after five months of treatment, whereas it decreased in normal-weight and overweight patients in comparison with control subjects. In bulimics more significant relations between body composition variables were found than in the controls. *Conclusion* Body composition of bulimia nervosa patients may show great differences related to their (varying) body weight. Future research should take the patients' body weight into account.

Key words bulimia nervosa – body composition – densitometry – anthropometry – skinfold measurements – underwater weighing – females

Introduction

Bulimia nervosa (BN) is characterized by recurrent binge eating (at least two times a week for three months) in combination with compensatory weight-controlling behaviors such as self-induced vomiting, abuse of laxatives or diuretics, episodes of restrictive food intake and excessive exercising (A. P. A. 1994). The majority of patients remain at normal weight, i. e. they maintain a body weight above 85 % of average body weight (Weltzin et al. 1991), but they have chaotic eating patterns that vary within as well as between individuals (Hetherington et al. 1994). Consequently many patients show great weight fluctuations. In contrast to anorexia nervosa, which is less prevalent, there are only a few studies on body composition in BN and all with a rather low sample size (Gwirtsman et al. 1989; Devlin et al. 1994; Detzer et al. 1994; Obarzanek et al. 1991; Howat et al. 1989). Moreover these studies assess normal weight BN. In this subgroup they did not find significant differences for percentage body fat between patients and normal healthy females.

According to the existing research one would expect no significant differences in body composition between

BN patients and normal healthy women. On the other hand we might assume that bulimic women despite a statistically normal weight would show physiological abnormalities due to the distorted eating behavior (binge eating, periods of food restriction) and compensatory behavior (purging). Altered eating patterns may result in alterations in body composition. Perhaps the paucity of research findings so far was due to the small sample sizes and the lack of differentiation with respect to body weight. Therefore, we wanted to study the body composition in a large sample of BN patients, as we did previously in anorexia nervosa patients (Probst et al. 1996, 2001), using the more "classic" methods such as the densitometric technique or underwater weighing (UWW) and the anthropometric approach of measuring skinfold-thickness (SFT). The aims of our study are 1) to compare these two methods (testing the concurrent validity) and to evaluate the body composition in BN; the hypothesis examined was that the SFT equation would produce accurate body fat estimation; 2) to compare underweight, normal-weight and overweight bulimic patients with sedentary subjects without disordered eating, and 3) to examine the course of body composition after five months treatment of the eating disorder.

Method

Subjects

The study was limited to non-obese female adolescents and young adults. The inclusion criteria were for both groups: an age younger than 28 years, a body mass index (BMI) lower than 30, and no use of medication known to affect body composition. One hundred and thirty eight female patients who met DSM-IV (A. P. A. 1994) criteria for BN admitted at the inpatient Eating Disorder Unit of the University Center Kortenberg (Belgium) were included in the study. Data were collected between 1995–2002 following a standard procedure. Patients with concurrent organic illnesses were excluded. The duration of the BN in our patient sample averaged 4.9 (±3.3) years with a range of 1 year to 15 years.

To serve as a comparison group 188 healthy sedentary female subjects were assessed following the same standard procedure. Recruitment of the control subjects (CS) was performed with collaboration of university students. None of these subjects reported significant psychiatric or medical illness nor symptoms of an eating disorder.

Due to the great variance of the body weight, both samples were classified in three subgroups (underweight, normal-weight and overweight) according to BMI (<20, 20–25, >25). Eighty patients have been retested after about five months (average interval of 148 ± 37 days). Data were available for 49 sedentary controls after a similar time interval (155 ± 15 days). Baseline characteristics are listed in Table 1.

Procedure

Research procedures were integrated as part of the treatment program and were approved by the Ethical Com-

Table 1 Physical characteristics and body composition in underweight, normal-weight and overweight female bulimia nervosa patients and healthy females

Underweight (BMI < 20)	Bulimia nervosa N = 57	Healthy females N = 58
Age (y)	22.7 (3.8)	21.6 (2.5)
Height (cm)	166.2 (7.0)	167.6 (6.0)
Weight (kg)	52.3 (4.5)	53.2 (4.6)
BMI (kg/m^2)	18.9 (0.6)	18.9 (0.7)
Densitometry		
Body fat (%)	21.5 (3.6)	23.9 (2.9)*
Fat mass (kg)	11.3 (2.4)	12.8 (2.3)*
Fat-free mass (kg)	41.0 (3.5)	40.4 (3.1)
Anthropometry		
Body fat (%)	21.7 (3.8)	23.9 (3.2)*
Fat mass (kg)	11.4 (2.6)	12.7 (2.4)**
Fat-free mass (kg)	40.9 (3.4)	40.7 (3.3)
Normal-weight (BMI 20–25)	**N = 57**	**N = 105**
Age (y)	20.5 (3.2)	20.8 (2.3)
Height (cm)	165.2 (6.6)	166.3 (5.6)
Weight (kg)	60.2 (5.7)	60.9 (5.3)
BMI (kg/m^2)	22.0 (1.3)	22.0 (1.3)
Densitometry		
Body fat (%)	26.6 (4.2)	26.5 (3.6)
Fat mass (kg)	16.1 (3.7)	16.2 (2.9)
Fat-free mass (kg)	44.1 (3.6)	44.7 (3.9)
Anthropometry		
Body fat (%)	27.5 (4.1)	27.6 (3.4)
Fat mass (kg)	16.7 (3.7)	16.9 (2.9)
Fat-free mass (kg)	43.5 (3.4)	44.0 (3.7)
Overweight (BMI > 25)	**N = 24**	**N = 25**
Age (y)	21.0 (3.7)	21.4 (2.0)
Height (cm)	166.4 (7.0)	165.8 (4.8)
Weight (kg)	74.6 (6.4)	72.5 (5.9)
BMI (kg/m^2)	26.9 (1.5)	26.4 (1.3)
Densitometry		
Body fat (%)	36.4 (2.9)	33.3 (3.1)*
Fat mass (kg)	27.2 (3.4)	24.2 (3.6)**
Fat-free mass (kg)	47.5 (4.2)	48.2 (3.3)
Anthropometry		
Body fat (%)	35.7 (3.5)	34.8 (3.2)
Fat mass (kg)	26.8 (4.4)	25.3 (3.7)
Fat-free mass (kg)	47.9 (3.7)	47.1 (3.3)

Values are means and standard deviations. * $p < 0.001$,** $p < 0.01$

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mittee of the University Center. All subjects gave informed consent to participate in the study. UWW is considered to be the method of reference for body composition. It is characterized by excellent reliability and validity. SFT is a classic technique that measures only subcutaneous adipose tissue, with a generally weaker reliability (but usually above r = 0.90) and a lower validity. The correlation between UWW and SFT ranges from 0.65 to 0.93 (Heymsfield et al. 1995).

A standard protocol of all anthropometric and densitometric assessments has been executed within 3 days of admission and once again at the end of the treatment, after about five months by the same female and highly experienced investigator. Height was measured to the nearest completed 0.5 cm using a stadiometer. Body weight was measured, with the subject wearing only a swimsuit, on a beam balance to the nearest 100 g. The Quetelet or Body Mass Index (BMI, kg/m^2) was calculated.

Twelve skinfolds were measured (Probst et al. 1996; Heymsfield et al. 1995; Weiner et al. 1969; Brown et al. 1977): biceps, triceps, subscapular, suprailiac, chin, side, waist, abdomen, thigh anterior and posterior, calf lateral and medial on the left side of the body, using a Harpenden electronic readout (HERO) skinfold caliper (Jones et al. 1979). The precision (test-retest) of our skinfold measurement fluctuated from r = 0.93 (for thigh posterior) to r = 0.97 (for the suprailiac). The percentage body fat (%fat) was estimated from the logarithm of the sum of the skinfold measurements taken at four sites (biceps, triceps, subscapular and supra-iliac) and the prediction equations using the age specific equations (density = 1.1599–0.0717 × log 4 skinfolds) of Durnin and Womersley (1974). For the girls below 16 years of age (N = 18), we used the same formula (density = 1.1549–0.0678 × log 4 skinfolds) as for the girls below 20 years of age.

Hydrodensitometry (UWW) calculates body volume as the difference between body weight measured in air and in water (based on Archimedes' principle that body volume is equal to the loss of weight in water). Modern hydrodensitometry systems consist of a scale within a large heated tank of water (37 °C). The subject exhales maximally, while totally immerged, and body weight is then recorded. The body weight (accurate to the nearest ±10 g) in water is measured at least six times. The highest value of the measurements is taken. Body density (D) is calculated with the following formula:

$$D = \frac{W}{\frac{W - Ww}{dw} - (RV + GI)}$$

In this formula, W is body weight in the air, Ww is body weight in water (after maximal expiration), dw is the density of the water, RV is the correction for the residual lung volume (measured two times at the time of taking Ww by helium dilution), and GI is the correction for the volume of gas in the gastrointestinal tract; 150 ml seems the most appropriate correction (Lasser et al. 1975, 1976). The precision of the measurement (test-retest) in our laboratory is r = 0.96. The percentage of body fat (%fat) is calculated by the Siri (1956) equation: percentage fat = (4.95/D –4.50) x 100.

An estimation of percent trunk fat, percent extremity fat and trunk/extremity ratio were calculated from skinfold measurements using the following formulae:

Percent trunk fat = sum of upper body skinfolds (subscapula, suprailiac, side, waist, abdomen, chin)/sum of 12 skinfolds; percent extremity fat = sum of extremity skinfolds (biceps, triceps, thigh anterior and posterior, calf lateral and medial)/sum of 12 skinfolds; trunk/extremity ratio = percent trunk fat/percent extremity fat.

All patients followed the same treatment protocol for normalizing eating habits (Vandereycken et al. 1984). They received the regular hospital menu (three meals per day with a total of 8.65Mj or 2100 kcal) and beside two snacks they were not allowed to eat anything else. With the "social control" of the inpatient group treatment program bingeing and purging were expected to stop completely within two weeks. When needed weight restoration took place gradually. Once the binge-purge episodes were under control, underweight patients received extra protein drinks and overweight patients followed a diet of 1600 or 1800 kcal/day. Patients were weighed every morning during the first month, three times a week during the second and third month, and finally only once a week during the remaining part of the treatment. Regular physical exercise was allowed (except if patients were underweight) with emphasis on exercising "for fun" as part of the therapeutic program of rebuilding a positive body experience.

Data analysis

Descriptive statistics were calculated for all variables. The relations between the body composition variables were assessed by Pearson Product Moment Correlations. Spearman rank correlation was assessed when appropriate. Differences of body composition within groups were evaluated using a two-tailed student t-test. A method proposed by Bland and Altman (1986) for assessing agreement between two methods was used to compare accuracy of the skinfold prediction before and after weight gain. Differences between individual UWW %fat values and individual skinfold %fat values were plotted against the mean of the two measures (UWW + SFT/2). The scatter plot was evaluated by assessing the variability method, included in two standard deviations (SD) above and below the mean. Differences in fat measurements were assessed using the SFT and

UWW procedures. We calculated Product Moment Correlations, Standard Error of Estimate (SEE = SDx square root $1-r^2$, where SDx is the SD of the UWW procedure), percentage of subjects whose skinfold %fat values were within 3.5 % of UWW %fat, and pure errors

$$(E = \sqrt{\frac{\sum (UWW-SFT)^2}{n}}$$

where UWW is %fat by UWW and SFT is %fat estimated by the skinfold equation).

A MANOVA procedure with repeated measures was used to analyze the group differences (BN versus CS) between BMI categories and was conducted to test for a main time effect. Post hoc contrasts were conducted by the Scheffé method for complex contrasts. P values of less than 0.05 were regarded as significant. All data were coded and computerized using Statistica (1998).

Results

Subjects profile

The physical characteristics and body composition variables for three subgroups of bulimic and normal subjects are listed in Table 1. Bulimics and controls were of similar age, height and weight. No significant differences were found on the clinical and demographic variables between patients and control subjects, between underweight, normal-weight and overweight groups, between retest (n = 80; n = 49) and non-retest groups (n = 58; n = 139). A two way MANOVA groups (BN and sedentary) x BMI categories (BMI < 20, BMI 20–25, BMI > 25) for variables age, weight, height, BMI, percentage body fat, fat mass and fat free mass showed a significant effect (Wilks Lambda = 0.86; df 14,612, p = 0.0004). Post hoc Scheffé test showed no differences in the normal-weight group. The normal-weight groups did not differ significantly in body composition by any of the methods employed. In the underweight and overweight subjects, respectively, there is a significantly lower and higher percentage body fat and fat mass in the BN patients compared to normal subjects.

Comparison of methods

The differences between UWW and SFT for each group separately are shown in Table 2.

The correlations between SFT and UWW %fat values were significantly high to very high. In the bulimic groups, we found higher correlations than in the control groups. Although the mean SFT %fat value was significantly higher than the mean UWW %fat in the normal-weight bulimics, normal-weight controls and overweight controls, the real difference was quite small. More than 80 % of the BN patients and control subjects had a SFT %fat within 3.5 % of UWW fat values. The E value for all groups was similar in magnitude to SEE's for effective prediction. For both groups the E values were within acceptable limits (3.8 % fat, as proposed by Lohman, 1992). The scatter plots of the difference and the mean of the two %fat measurements by UWW and SFT for each BN group is shown in Fig. 1.

Subcutaneous fat

For 12 overweight BN patients the minimum data of the thighs were given due to the limitations of the apparatus to measure skinfolds greater than 60 mm. In the under-

Table 2 Comparison of mean percentage body fat (%fat) estimated by underwater weighing (UWW) and by skinfold-thickness (SFT) in weight subgroups of bulimia nervosa patients (BN) and control subjects (CS)

	%fat	Difference	Min – Max	D	E	SEE	R	t (UWW-SFT)
Underweight								
BN-UWW	21.5±3.6		15.4–31.1					
BN-SFT	21.7±3.8	–0.245±1.8	14.2–33.1	93 %	1.85	1.73	0.88*	1.00
CS-UWW	23.9±2.9		15.5–30.7					
CS-SFT	23.9±3.2	–0.033±2.62	18.3–32.2	91.4 %	2.60	1.92	0.64*	0.10
Normal-weight								
BN-UWW	26.6±4.2		18.9–37.1					
BN-SFT	27.5±4.1	–0.848±2.3	19.6–40.2	82.5 %	2.47	2.26	0.84*	2.73*
CS-UWW	26.5±3.6		17.7–34.8					
CS-SFT	27.6±3.4	–1.130±2.2	20.5–37.1	87.6 %	2.49	2.16	0.80*	5.19*
Overweight								
BN-UWW	36.4±2.9		31.2–41.0					
BN-SFT	35.7±3.5	0.626±2.3	30.0–44.1	87.5 %	2.37	2.22	0.75*	1.31
CS-UWW	33.3±3.1		27.0–39.6					
CS-SFT	34.8±3.2	–1.529±2.3	28.7–41.3	80 %	2.74	2.10	0.73*	3.30*

D percentage of subjects with SFT %fat within 3.5 % of UWW %fat values; *E* pure error; *SEE* standard error of estimate; *t* t-test; *p < 0.01

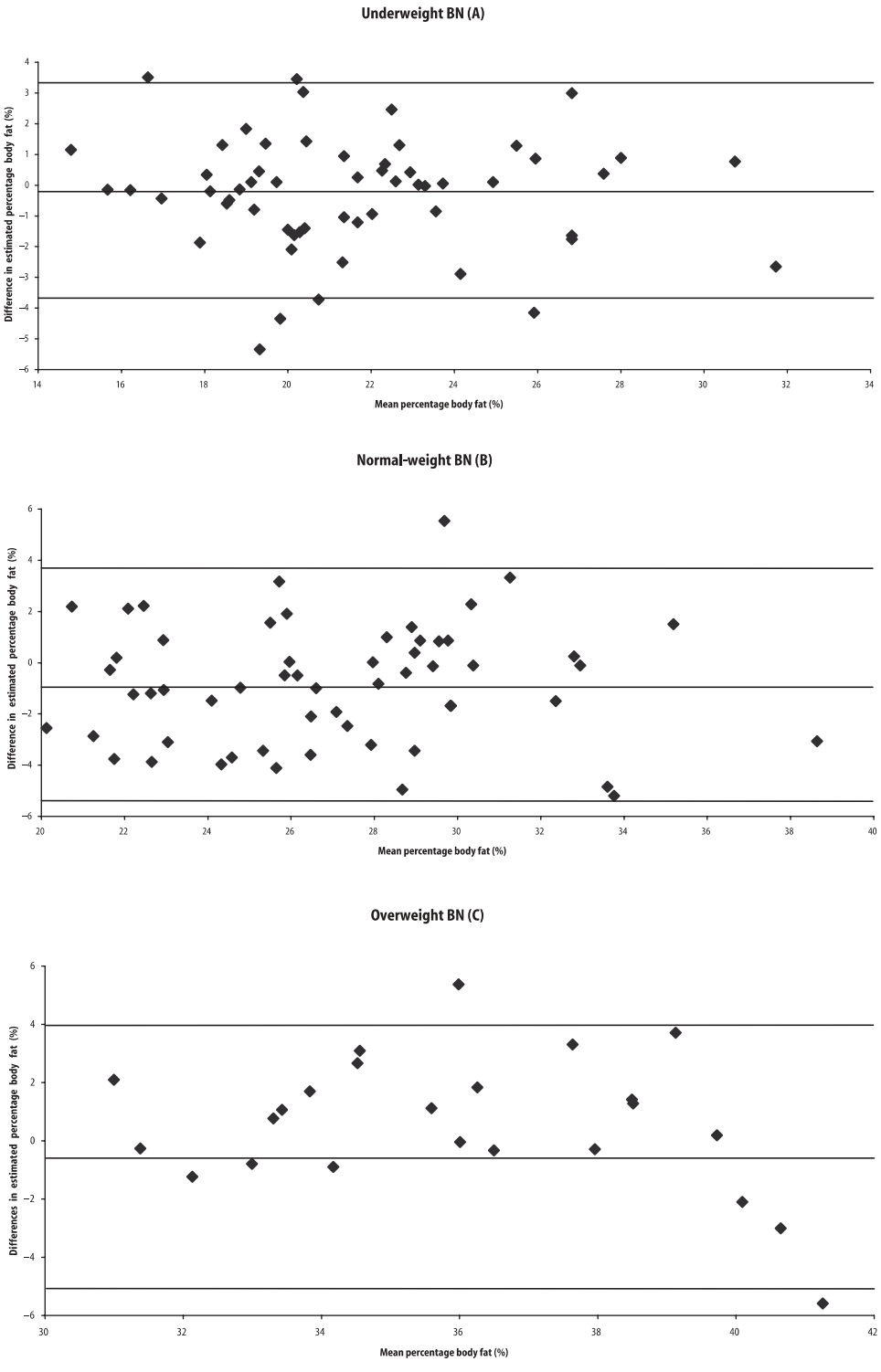

Fig. 1 Agreement assessment according to the Bland-Altman method [11] between percentage body fat estimated by underwater weighing and skinfold-thickness prediction in underweight (**A**), normal-weight (**B**) and overweight (**C**) patients with bulimia nervosa. Means are plotted against the difference between the two procedures. The center line represents the mean difference between the two methods and the other lines represent two standard deviations from the mean (95 % confidence interval)

weight group the SFT of biceps, triceps, waist, thigh and calf were significantly lower in the patient group. In the normal-weight group only the calf lateral was significantly lower in patients, in the overweight group the thighs were significantly higher in bulimics (see Table 3). Simple correlations between anthropometry measures and UWW %fat and SFT %fat are shown in Table 4. In BN patients, the most significant correlations between the different skinfolds and percentage body fat were found in the triceps. In the control groups the cor-

Table 3 Skinfold thickness in weight subgroups of bulimia nervosa patients (BN) and control subjects (CS).

	Underweight		Normal-weight		Overweight		
Skinfolds (mm)	BN (a)	CS (b)	BN (c)	CS (d)	BN (e)	CS (f)	
Biceps	6.8±2.4	8.3±2.2	10.6±4.3	11.5±3.7	17.3±5.8	16.7±4.0	*a/b
Triceps	12.7±3.8	15.1±3.8	18.5±6.2	19.0±4.8	28.8±6.2	26.5±6.6	*a/b
Subscapula	10.0±3.9	11.0±3.0	14.7±4.9	14.5±4.4	26.9±9.9	24.3±6.7	
Suprailiac	6.8±2.5	7.2±2.5	12.1±5.6	10.7±4.6	26.0±10.4	22.6±9.3	
Side	9.1±3.8	9.9±3.0	14.0±4.9	13.3±4.5	25.5±7.7	24.1±8.7	
Waist	13.8±5.2	16.6±6.0	22.2±8.3	23.3±7.9	35.3±10.3	36.2±7.9	*a/b
Abdomen	10.7±4.9	11.8±3.9	15.2±6.6	15.4±5.9	29.9±8.6	28.7±8.8	
Chin	8.6±2.2	8.2±1.9	10.6±2.7	10.1±2.4	14.2±3.2	12.9±2.9	
Thigh anterior	22.8±7.9	27.9±7.8	34.6±9.7	35.8±9.1	> 56.6±6.8	50.0±7.8	*a/b,e/f
Thigh posterior	24.1±7.4	29.7±8.8	37.5±9.4	37.0±8.9	> 52.7±6.0	46.4±8.6	*a/b,e/f
Calf lateral	11.9±3.4	14.8±4.5	16.1±5.8	18.6±5.7	25.0±5.5	21.9±6.3	*a/b,c/d
Calf medial	12.5±3.9	15.6±4.8	18.4±7.0	19.9±6.6	29.4±6.6	26.2±8.2	*a/b
Upper body[1]	59.0±19.3	64.7±16.8	88.7±27.8	86.8±24.4	154.4±37.1	148.8±37.3	
Extremity[2]	90.7±24.3	111.4±25.0	132.8±31.4	142.1±31.0	> 209.9±26.6	187.8±33.9	*a/b,e/f
Total body	149.7±39.4	176.0±35.2	218.4±48.5	229.5±49.5	> 370.0±63.9	336.6±59.6	*a/b
% trunk fat[3]	39.2±6.0	36.8±5.9	39.2±5.4	37.7±5.4	±40.1±4.7	44.0±5.8	
% extremity fat[3]	60.8±5.9	63.2±5.9	60.8±5.4	62.3±5.4	±59.9±5.3	56.0±5.8	
%trunk fat/%extremity fat	66.2±17.5	59.6±15.9	65.9±16.0	61.8±15.3	±74.0±14.6	80.3±18.8	

* $p < 0.01$
[1] Upper body: subscapula, suprailiac, side, waist, abdomen and chin; [2] Extremity: biceps, triceps, thigh anterior & superior, calf lateral & medial; [3] % trunk (extremity) fat: upper body (extremity)/total body × 100

Table 4 Relation between body fat (%fat) estimated by underwater weighing (UWW) and by skinfolds-thickness (SFT) in weight subgroups of bulimics and controls

	BN patients		Control subjects	
	UWW %fat	SFT %fat	UWW %fat	SFT %fat
Underweight				
BMI	0.39*	0.48	0.25*	0.38*
Sum of 12 skinfolds	0.79	0.91	0.69	0.73
Sum upper body	0.76	0.97	0.62	0.73
Sum extremity	0.68	0.80	0.56	0.54
Biceps SFT	0.68	0.82	0.43	0.65
Triceps SFT	0.77	0.86	0.59	0.75
Subscapular SFT	0.71	0.83	0.60	0.74
Suprailiac SFT	0.73	0.81	0.61	0.70
Normal-weight				
BMI	0.71	0.66	0.49	0.56
Sum of 12 skinfolds	0.79	0.92	0.77	0.87
Sum upperbody	0.71	0.89	0.76	0.87
Sum leg	0.74	0.83	0.61	0.67
Biceps SFT	0.75	0.83	0.52	0.72
Triceps SFT	0.76	0.91	0.62	0.81
Subscapular SFT	0.74	0.90	0.67	0.71
Suprailiac SFT	0.58	0.78	0.67	0.78
Overweight				
BMI	0.64	0.74	0.60	0.56*
Sum of 12 skinfolds	0.68	0.92	0.76	0.88
Sum upperbody	0.73	0.90	0.65	0.84
Sum leg	0.49*	0.62	0.62	0.62
Biceps SFT	0.47*	0.64	0.60	0.63
Triceps SFT	0.64	0.62	0.47	0.75
Subscapular SFT	0.50*	0.83	0.47	0.69
Suprailiac SFT	0.63	0.91	0.69	0.85

All $p < 0.001$ except * $p < 0.05$

relation was also significant but lower. The relation between UWW %fat and the sum of upper and extremity skinfold significantly high were for all groups.

Percentage body fat and BMI

Although the relations between BMI and body fat estimated from SFT and UWW were strong ($r = 0.87$) for the total patient sample, in the subgroups this relation was not so strong (see Table 4). 15 to 44 % of the variance in percentage body fat may be predicted by BMI. In the sedentary group the relation is low significant in the underweight group and moderate in normal-weight and overweight groups. The variations in percentage body fat at any given BMI were great in both groups: with a BMI of 19, for example, the range of UWW %fat for patients is 17.6–31.1 % and for control subjects 15.5–30.7 %. Additional analyses concerning the relationship between the frequency (never–sometimes–weekly–daily) of compensatory behaviors (diet, vomiting, binge and use of laxatives) in BN and percent body fat is significant but very low for all variables (Spearman rank correlation $r = 0.20$; $p = 0.05$). For the BMI only a significant but low relation is found with frequency of binge eating ($r = 0.26$; $p < 0.01$).

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Course of body composition after five months

In the BN-group the relation between PBF over a period of five months, measured by rank correlation, was for the underweight group r = 0.79 and the normal-weight group 0.70 for UWW and SFT ($p < 0.001$). In the overweight patients we found 0.69 ($p < 0.01$) and 0.89 ($p < 0.01$) respectively for UWW and SFT. In the control group the correlation was 0.90 ($p < 0.01$) for both methods in the underweight and normal-weight subjects and 0.81 in the overweight subjects. These results indicate that the ranking order is maintained. A three way repeated measures MANOVA between bulimic versus control and weight subgroups, for BMI, UWW %fat, fat mass and fat free mass showed a significant interaction (Wilks' Lambda = 0.48, df 10,238, $p < 0.000001$). Post-hoc Scheffé test ($p < 0.05$) showed that weight, BMI, percentage fat and fat mass were significantly lower after five months in the normal-weight and overweight bulimics (see Table 5). For the underweight patients all variables increased significantly. In the control group no differences were found after five months. No significant difference was found at baseline between patients and controls, but after five months underweight bulimics showed significantly higher values. In the normal-weight subgroup BN patients had significantly lower values after five months compared to controls. Additional two-way repeated measure ANOVA between weight subgroups of BN patients showed a significant effect ($F [2, 123]$ 18.9, $p < 0.0001$) for percentage body fat. UWW %fat increased in the underweight category and decreased significantly in the normal-weight and overweight group (see Fig. 2). Additional repeated measures analyses in the different weight subgroups separately between bulimics and controls for the percent trunk fat, extremity fat and percent trunk/extremity ratio showed no significant interaction.

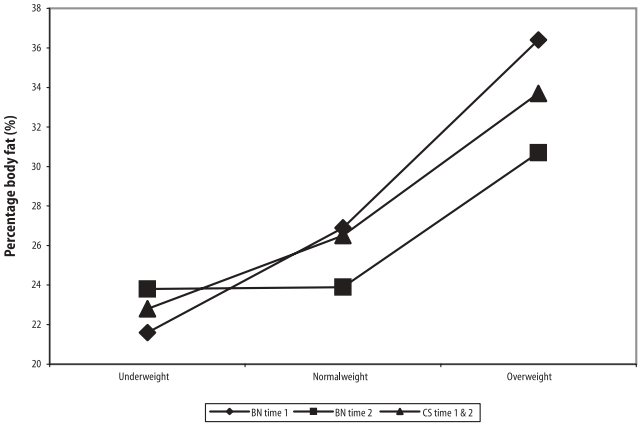

Fig. 2 Plot of means of percentage body fat between underweight, normal-weight and overweight bulimia nervosa patients (BN) and healthy control subjects (CS) at baseline and after five months

Table 5 Body composition in weight subgroups of bulimic patients and control subjects at baseline (time1) and after five months (time 2)

	Bulimia nervosa		Control subjects		
Underweight	Time 1 (a) N = 34	Time 2 (b)	Time1 (c) N = 9	Time 2 (d)	
Weight (kg)	53.3±4.3	56.0±4.1	50.3±5.7	50.4±6.4	*a/b,b/d
BMI (kg/m^2)	18.9±0.6	19.9±0.6	18.7±0.6	18.7±0.9	*a/b,b/d
UWW body fat (%)	21.8±3.6	23.7±3.4	22.8±2.6	22.6±2.0	*a/b
UWW fat mass (kg)	11.6±2.4	13.3±2.2	11.5±2.0	11.4±1.9	*a/b,b/d
UWW fat-free mass (kg)	41.6±3.4	42.7±3.5	38.9±4.4	39.0±4.7	*a/b,b/d
Normal-weight	N = 32		N = 32		
Weight (kg)	59.6±5.9	56.4±5.3	61.9±5.4	62.1±5.7	*a/b,b/d
BMI (kg/m^2)	22.0±1.4	20.8±0.9	21.9±1.3	22.8±1.5	*a/b,b/d
UWW body fat (%)	26.6±4.3	23.8±3.1	26.6±4.0	26.6±3.8	*a/b,b/d
UWW fat mass (kg)	16.0±3.7	13.5±2.6	16.5±3.2	16.6±3.3	*a/b,b/d
UWW fat-free mass (kg)	43.6±3.5	42.9±3.6	45.4±4.0	45.5±4.1	*a/b,b/d
Overweight	N = 14		N = 8		
Weight (kg)	76.2±6.8	68.4±8.3	73.3±8.3	73.5±8.6	*a/b
BMI (kg/m^2)	27.0±1.5	24.1±2.0	27.0±1.8	27.0±1.3	*a/b,b/d
UWW body fat (%)	36.7±2.7	31.1±4.2	32.7±3.0	32.8±2.0	*a/b,a/c
UWW fat mass (kg)	28.0±3.4	21.4±4.9	24.2±4.2	24.2±4.0	*a/b
UWW fat-free mass (kg)	48.2±4.6	47.0±4.6	49.1±4.7	49.3±4.8	*a/b

* $p < 0.01$

Discussion

Unlike anorexia nervosa studies of body composition in BN patients (Gewirtsman et al. 1989; Devlin et al. 1990; Obarzanek et al. 1991; Detzer et al. 1994) sparse and mostly based on small samples (from 8 to 29 patients). This study is based on the two-component model (fat mass and fat free mass including water proteins and minerals) and simultaneously compared two traditional methods of measurement in a large group of BN patients and control subjects. The findings of this study indicate that the SFT method for estimating body fat was in agreement with the UWW method for bulimics and determine the applicability and suitability of SFT for use in the field of bulimia nervosa (see Heyward and Stolarczyk 1996, p. 220). In the normal-weight subgroups and the overweight control group there was a statistically significant but small difference between both methods. The estimation from SFT shows higher percentage body fat.

The results for anthropometric and body composition indexes of both bulimics and controls showed no signs of malnutrition. All measurements were within the normal range for the subjects' age. Normal-weight bulimic patients did not differ from normal-weight sedentary subjects on body composition, thus confirming the results of previous studies (Howat et al. 1989; Detzer et al. 1994). But one of the major findings of the present study was that underweight (BMI < 20) and overweight (BMI > 25) bulimics did differ significantly for percentage body fat (and fat mass) from the healthy females, the former showing lower and higher values respectively. These findings underscore the importance of subdividing BN patients according to BMI values, as suggested by other researchers (Marcos et al. 1997).

After five months of treatment percentage body fat and fat mass increased in underweight bulimics and decreased in normal-weight and overweight patients. Especially the latter two subgroups of patients fear that normalization of their eating behavior would lead to (excessive) weight gain, but our results clearly show this is not the case. The ratio trunk/extremity fat is an estimation based on skinfold measurements that gives an indication about the distribution of fat. In this study we have found that %trunk fat, %extremity fat and ratio %trunk/extremity fat in BN patients and control subjects of different BMI are equal. The BMI reflects real changes in the weight/height ratio but in spite of the high correlation with percentage body fat it is not a direct index or predictor of relative body fatness (Prentice, 2001). BMI is a misleading measure and certainly in eating disorders it is time to take a standard based on actual measurements of body fat, taking into account the influence of age.

Due to the clinical setting this study shows little limitations because of uncertainties in food intake (see Gendall et al. 1997; Hetherington et al. 1994), in physical activity and in the amount of current cigarette smoking (see Perkins et al. 1989; Klesges et al. 1989). At the same time, these limitations are recommendations for further detailed research. In this study these limitations however are countered for a part by the large sample and minimise the influence of these variables. Future research of bulimic patients should also include more detailed information on the lifetime history of anorexia nervosa or obesity (weight cycling) (see Fairburn et al. 1979) and the menstrual functioning (use of contraceptives) (see Rock et al. 1996).

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