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RESEARCH

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The Relationship between Body Mass Index and Body Size Dissatisfaction in Young Adolescents: Spline Function Analysis

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ABSTRACT

This study assessed how body size dissatisfaction (BSD) varies in relationship to specific body mass index (BMI) values in a sample of preadolescents. A novel statistical approach based on spline function, suitable to assess in detail how two variables are related, was used. The study was conducted between December 2004 and March 2005. Students (aged 11 to 14 years) from seven selected secondary schools in Verona, Italy, were invited to participate. The final study group included 678 subjects. BSD was assessed using the Body Image Assessment Procedure. BMI values were expressed as z scores. It was found that, in the total sample, slightly underweight subjects (BMI z scores$=-0.5$) had no BSD. BSD progressively increased (current body size > ideal body size) for BMI z scores >-0.5 and became negative (ideal body size > current body size) for BMI z scores <-0.5. In boys, average weight subjects had no BSD. BSD progressively increased for BMI z scores >0 and became negative for BMI z scores <0. In girls, moderately underweight subjects (BMI z scores$=-1$) had no BSD. BSD progressively increased for BMI z scores >-1 and became negative for BMI z scores <-1. Although sex significantly moderated the relationship between BMI and BSD ($P<0.001$), socioeconomic status did not ($P=0.459$). Because average weight and slightly underweight young girls desired a thinner body, our study suggests that these subgroups should receive particular attention in public health programs as well as in dietetics clinical practice.

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Body image relates to a person's perceptions, feelings, and thoughts about his or her body, and is usually conceptualized as incorporating body size estimation, evaluation of body attractiveness, and emotions associated with body shape and size (1). Concerns with body image, including body size dissatisfaction (BSD), are common among adolescents (2-5). They are associated with emotional distress, low self-esteem, and increased risk for eating disorders (6,7).

Most (8-12), although not all (13,14), studies have reported a significant positive correlation between body mass index (BMI) and BSD. However, these studies used statistical analyses suitable to estimate only whether BMI and BSD are associated. No epidemiologic studies have investigated in detail how BMI and BSD are associated. Such a detailed analysis would provide information on the specific BMI categories that display BSD. This, in turn, would offer insight into what factors might be useful to include in health programs that target specific weight groups. Such analysis would also provide useful insights for clinical practice, suggesting which weight categories should receive particular attention in the management of BSD.

Moreover, it is still unclear how sex (3) and socioeconomic status (SES) (15-17) moderate the inter-relationship between BMI and BSD in preadolescents.

The aim of our study was to assess how BSD relates to specific BMI values and the influence of sex and SES on this relationship. It was decided to only include young adolescents to collect data that could potentially be useful for prevention programs addressing BSD in this young population.

METHODS

Design and Participants

During October 2004, seven junior high schools in Verona, Italy, were randomly selected and stratified to generate a socioeconomically diverse sample. All students (aged 11 to 14 years), except those with certified learning disabilities, were eligible for inclusion. The protocol was approved by the local ethics committee. Data collection was carried out between December 2004 and March 2005. Informed written consent was obtained from the parents of all participants and written assent was obtained from all the participants.

Measures

Anthropometry. Height was measured to the nearest 0.5 cm on a standardized height board. Weight was rounded to the nearest 0.1 kg on a standard beam scale. BMI values were standardized (BMI *z* scores) using age- (to the nearest sixth month) and sex-specific median, standard deviation, and power of the Box-Cox transformation (least mean squared method) based on Italian norms (18).

SES. SES was estimated as reported in la Torre and colleagues (19). Families' socioeconomic levels were classified as: "Very High," "High," "Middle," or "Low or Very Low."

Assessment of BSD. The Body Image Assessment Procedure for Pre-Adolescents (20) consists of two sets of silhouettes—male and female, ranging from very thin to obese. The cards are placed on a table in front of a subject in random order. The subject is given the following instructions: "I want you to point to the one that looks most like you." The card number is the score for current body size (CBS). The cards are reshuffled and presented to the subject once again with the following instructions: "I want you to point to the one that you would most want to look like if you could look like any of these." The card number is the score for ideal body size (IBS); that is, how the subject would most like to look. The difference between CBS and IBS provides the score for BSD. Normative data (*T* scores for CBS, IBS, and BSD) for Italian children are available (21).

Statistical Analysis

The relationship between BMI *z* scores and BSD was assessed using a thin-plate penalized regression spline model. This function is suitable for determining the relationship between a dependent variable and a quantitative explanatory variable when there is a specific interest in the details of the relationship, particularly for nonlinear relationships. The regression spline model relies on the estimation of general additive models with a penalized regression spline (22). These models are similar to multiple linear regression models. However, contrary to multiple linear regression, some explanatory variables are not analyzed per se, but are transformed optimally with a piecewise cubic spline function. This cubic spline function aims to find the best fitting curve, representing the link between the dependent and the independent variables using cubic polynomials on a succession of consecutive intervals. The statistical tests (Wald tests) and the estimation of the spline are obtained through an iterated call to a general linear mixed effects model. To avoid overparameterization and so-called wiggliness of the fitted model, a constraint is added to the algorithm that leads to the penalized regression spline model (22). R software (version 1.0.0, 2000, R Developmental Core Team, Vienna, Austria) and the multiple generalized cross validation package (22) were used. A probability level of $P<0.05$ was used to indicate statistical significance.

RESULTS AND DISCUSSION

A final sample of 678 subjects (79.9% of the registered students) was used for the statistical analysis.

The demographic and anthropometric characteristics of the subjects are reported in the Table. Interestingly, the BMI distribution of the subjects was very similar to that reported in the United States, according to national growth charts (23).

Most of the subjects (see the Table) presented with a BSD=0 (ie, CBS=IBS). Only about 16% of subjects presented with BSD values ≥4, although about 26% of subjects had BSD values ≥3, corresponding approximately to the 75th percentile (21). Interestingly, the correlation value between BMI *z* scores and CBS ($r=0.55$, $P<0.01$), as well as the correlation value between BMI *z* scores and IBS ($r=0.03$, $P>0.05$) were very similar to those reported in a sample of American adolescents ($r=0.41$, $P<0.01$ and $r=0.04$, $P>0.05$, respectively) (20). Therefore, the distributions of CBS, IBS, and, as a consequence, BSD in relation to BMI *z* scores in this Italian sample might be very similar to those of the US population in the same age range.

BMI *z* scores and BSD scores were significantly associated in both the total sample, as well as in boys and girls separately ($P<0.001$ in all three samples).

In the total sample, the BMI *z* score at the zero BSD point (ie, no dissatisfaction) was about −0.5 (slightly underweight). BSD progressively increased (CBS > IBS) for BMI *z* scores >−0.5. For BMI *z* scores <−0.5, BSD became negative (IBS > CBS). The relationship between BMI and BSD cannot be considered linear, because slightly underweight children expressed body size satisfaction, whereas both children with BMI *z* score <−0.5 and children with BMI *z* scores >−0.5 displayed dissatisfaction with body size.

Sex was a significant moderator of the relationship between BMI *z* scores and BSD values (Wald test $P<0.001$).

In girls (see the Figure), the BMI *z* score at the zero BSD point was about −1 (moderate underweight). BSD progressively increased for BMI *z* scores >−1. BSD became negative for BMI *z* scores <−1. Therefore, slightly underweight, average weight, and overweight girls wanted to be thinner, whereas underweight girls wanted a heavier body. This is consistent with results from sev-

Table. Demographic data, anthropometric characteristics, and body size dissatisfaction (BSD) scores by sex and total sample of Italian pre-adolescents

	Boys (n=318)		Girls (n=360)		All (n=678)	
	← mean±standard deviation[a] →					
Age (y)	12.87±1.05		12.88±1.01		12.87±1.03	
BMI[a] scores	19.45±2.80		19.28±2.73		19.35±2.76	
BMI *z* scores	0.05±0.97*		−0.15±0.92		−0.05±0.95	
	← %[a] →					
≥85th BMI percentile	7.23		6.63		13.86	
≥95th BMI percentile	4.13		2.80		6.93	
≤5th BMI percentile	2.51		3.68		6.19	
	n	%	*n*	%	*n*	%
BSD score						
−3 (IBS[b] minus CBS[c]=3)	0	0.00	1	0.27	1	0.14
−2 (IBS minus CBS=2)	16	5.83	8	2.22	24	3.53
−1 (IBS minus CBS=1)	38	11.94	21	5.83	59	8.70
0 (CBS=IBS)	161	50.62	155	43.05	316	46.60
1 (CBS minus IBS=1)	48	15.09	104	28.88	152	22.41
2 (CBS minus IBS=2)	38	11.94	46	12.77	84	12.38
3 (CBS minus IBS=3)	11	3.45	15	4.16	26	3.83
4 (CBS minus IBS=4)	4	1.25	4	1.11	8	1.17
5 (CBS minus IBS=5)	1	0.31	2	0.55	3	0.44
6 (CBS minus IBS=6)	1	0.31	3	0.83	4	0.58
7 (CBS minus IBS=7)	0	0.00	1	0.27	1	0.14

[a]BMI=body mass index.
[b]IBS=ideal body size.
[c]CBS=current body size.
*P=0.006.

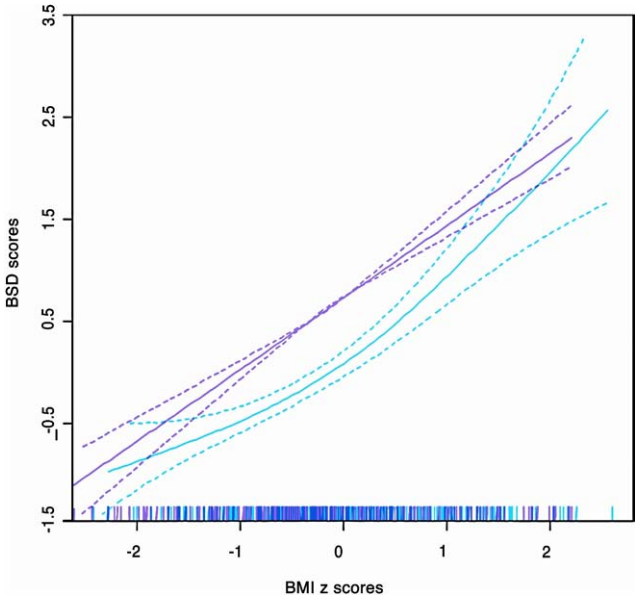

Figure. Spline function graph showing the relationship between body mass index (BMI) *z* scores and body size dissatisfaction (BSD) scores in girls (graph in purple) and in boys (graph in turquoise). The dashed lines on the plot represent the confidence interval.

eral studies in adult women indicating that female subjects have a thinner body ideal than the average (24). The results of this study also suggest that the desire for a thinner body in average weight girls expresses itself at a relatively young age (the mean age of girls was 12.88±1.01 years).

In boys (see the Figure), the BMI *z* score at the zero BSD point was about zero (average weight). BSD progressively increased for BMI *z* scores >0. BSD became negative for BMI *z* scores <0. Therefore, average weight subjects were satisfied with their body image; those with BMIs higher than average expressed a desire for a thinner body, whereas those with BMIs lower than average wanted a heavier body. Several authors have suggested that boys want a larger and more muscular body, even when they are at an average weight (3). However, there is also evidence that weight loss is a central aspect of body image in boys (3). In our study, boys with higher-than-average weight wanted a thinner body rather than a larger one. It is possible that the concerns for muscularity come later in mid-adolescence (age 14 to 16 years). However, it is also possible that boys from this sample wanted a thinner but more muscular body. The Body Image Assessment Procedure for Pre-Adolescents did not enable us to discriminate between a desire for a thinner body and a desire for thinner and more muscular body.

As for the mechanisms that may explain a significant relationship between BMI and BSD, the cross-sectional

nature of this study does not allow us to infer causality. It is probable that body weight contributes to BSD both directly and indirectly through teasing from others (10). Biological factors underlying the relationship between BSD and BMI have been suggested (8) but scarcely explored; thus, they deserve further research.

Finally, SES did not moderate the relationship between BMI *z* scores and BSD (Wald test $P=0.459$). This is consistent with previous studies showing that the relationship between BMI and BSD is more an issue of internalized cultural ideals than simply a reflection of SES (25). However, as most of the subjects (about 74%) in this sample belonged to SES=2 (middle), these results should be considered with caution.

Some limitations of the study should be addressed. First, it was not possible to analyze the moderating role of race because only 13.2% of subjects were nonwhite. This study sample cannot be considered representative of the multiethnic American population. Second, no data are available on those children who did not participate in the study. However, the mean BMI scores of the total sample (boys and girls) are similar to those found in an independent study conducted on a sample of children of the same age range and living in the same geographical area (26). It is likely that the BMI distribution of this sample was representative of the population in Verona, Italy, independent from the characteristics of the subsample that did not participate in the study. Third, the moderating effect of pubertal status was not assessed. Given the relatively large sample size and the setting of the study (classroom), it was not possible to assess pubertal status through a clinical examination.

CONCLUSIONS

This study provides insight into the inter-relationship between BMI and BSD in an Italian sample of young adolescents by means of a novel statistical approach, namely spline function analysis. Because the BMI values distribution and their correlation with CBS and IBS values were very similar to those reported in US samples of young adolescents, the results of this study might apply to the US population in the same age range, although a note of caution should be used because of the different ethnic composition of the Italian and US populations.

Despite its limitations, this study provides important results for dietetics practitioners in clinical practice as well as for programs calling for weight changes within the context of promoting healthy body image in preadolescents. The body size dissatisfaction found in both overweight and underweight boys and girls may put these subjects at risk for further distress and psychopathology (27,28); however, it may also stimulate appropriate and healthy weight changes. On the other hand, body size dissatisfaction observed in average weight and even slightly underweight girls may contribute to inappropriate and unhealthy weight loss. Therefore, from a clinical standpoint, dietetics practitioners and other professionals involved in issues surrounding weight management should consider that average weight and even slightly underweight preadolescent girls are not immune from BSD and should investigate the possibility of BSD in this population as well.

From a public health standpoint, average weight and slightly underweight young girls should not be ignored in health promotion programs targeting preadolescents. It is particularly noteworthy that the results were obtained in a sample of preadolescents, as it has been pointed out that programs targeting preadolescents are more effective than those addressing adolescents (29).

STATEMENT OF POTENTIAL CONFLICT OF INTEREST: No potential conflict of interest was reported by the authors.

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