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BRIEF COMMUNICATION

Assessment of body composition using bioelectrical impedance analysis in Prader-Willi syndrome

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This study investigated the use of bioelectrical impedance analysis (BIA) as a means of assessing body composition in patients with Prader-Willi syndrome (PWS). Segmental, multifrequency BIA was performed on 30 patients with PWS (16 males and 14 females; mean age: 8.1 ± 3.9 years; age range: 2.9–19.6 years) using eight tactile electrodes. No patient had received growth hormone treatment prior to baseline measurements. Standard deviation scores for height, weight, and body mass index were −0.96 ± 1.29, 2.28 ± 2.66, and 3.14 ± 2.74, respectively. Percentages of body fat, total body water, and soft lean mass were 45.9 ± 10.8%, 36.6 ± 7.3%, and 49.9 ± 9.9%, respectively. Body fat percentage was positively correlated with the body mass index standard deviation score ($r = 0.665$, $p < 0.01$). Follow-up BIA was also performed on five patients who received growth hormone therapy (duration of treatment: 1.5–4.6 years). All of these patients showed reductions in their body fat percentages after treatment. BIA confirmed a significantly higher percentage of body fat in patients with PWS compared with normal children. These findings and the follow-up data can be used to develop quality care strategies for patients with PWS.

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Introduction

Prader-Willi syndrome (PWS) is a congenital disorder characterized by neonatal hypotonia, a typical facial appearance, hypogonadism, short stature, childhood-onset obesity, hyperphagia, developmental delays, and behavior problems. Approximately 70–75% of cases result from deletion of the PWS-critical region on paternal chromosome 15q11-13, 25–28% result from maternal uniparental disomy (UPD), and the remaining 2–5% result from a mutation or deletion in the imprinting center or some another imprinting defect. Obesity usually develops in patients with PWS after the first year of life and often becomes severe if growth hormone treatment is not administered.[1–4] Brambilla et al[5] reported that children and adolescents with PWS have a peculiar body composition that is characterized by increased adiposity and reduced lean mass, even when compared with normal subjects with the same body mass index (BMI) who are simply obese.

Dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA) are both safe and easily accessible methods for assessing body composition.[6] Although DXA is accurate and reproducible,[5,7,8] it is complicated to perform and too expensive for routine clinical use. BIA, on the other hand, is a simple, inexpensive, and noninvasive method for evaluating body composition. Information regarding the use of this technique to evaluate patients with PWS is limited,[9,10] even though it has been widely used by other health care professionals, including health care researchers, fitness trainers, and researchers at weight-control clinics.[6,11–13] In this study, we report our experience of using eight-polar, segmental, multifrequency BIA to assess body composition in PWS patients. Our goal was to provide a simple method that could be used as a clinical reference to evaluate PWS patients.

Patients and methods

Selection of subjects

Thirty patients with PWS (16 boys and 14 girls; mean age: 8.1 ± 3.9 years; age range: 2.9–19.6 years) were enrolled in this study. This study was performed in three tertiary medical centers in the greater metropolitan area of Taipei, including Mackay Memorial Hospital, Taipei City Hospital, and Taipei Tzu Chi Hospital. None of the enrolled patients had received growth hormone treatment at the time of their baseline measurements for this study. Five patients were subsequently treated with growth hormones (0.1 IU/kg/day administered subcutaneously); these patients are included in the follow-up study. PWS was confirmed in all patients by genetic analysis. Informed written consent was obtained from a parent (for children under the age of 18 years) or directly from patients over 18 years of age. The study was approved by the ethics committee of Mackay Memorial Hospital, Taipei, Taiwan.

Segmental multifrequency BIA

Body composition was assessed by segmental multifrequency BIA using eight tactile electrodes (InBody 3.0; Biospace, Seoul, Korea). Body composition was assessed after an overnight fast at least 8 hours and within 30 minutes of voiding the urinary bladder. The subject was instructed to hold the electrodes in both hands and stand on the footplate with bare feet. Physical exercise was not allowed before the measurements were recorded. Analysis was conducted at multiple frequencies, including 5 kHz, 50 kHz, 250 kHz, and 500 kHz. The segmental impedances of the right arm, left arm, trunk, right leg, and left leg were measured at each frequency. Each measurement took about 2 minutes to complete, and the results were printed directly from the InBody 3.0 device, which automatically reported the values for fat mass, fat-free mass, and body fat percentage that were calculated from the impedance values using a previously described equation.[14]

Data analysis and statistics

Each patient's gender, age, genotype pattern, Holm's score,[1,15] height, weight, and BMI at the time of the study were recorded. A standard deviation score (SDS) was derived by subtracting the population mean from each individual's raw score and then dividing the difference by the standard deviation of the population. SDSs for height, weight, and BMI were calculated based on standard growth tables for Taiwanese children.[16] Results are expressed as the mean ± standard deviation unless otherwise indicated. Two-tailed paired t-tests were used to determine statistical significance. The effects of gender and genotype pattern on Holm's score; on SDSs for height, weight, and BMI; and on each BIA value were analyzed using two-way analysis of variance (ANOVA) using gender (males vs. females) and genotype pattern (deletion vs. UPD) as the main effects. The relationships between age and each BIA value and between body fat percentage and the other BIA values were tested using Pearson's correlation, and significance was tested using Fisher's r-z transformations. SPSS version 11.5 (SPSS Inc., Chicago, IL, USA) was used to perform the statistical analyses. Differences were considered statistically significant when $p < 0.05$. We also used published values for body fat percentage, as measured by BIA in normal Chinese children,[11] as the standard against which to compare the results obtained from the study patients.

Results

Genotype deletions were found in 25 patients (83%) and maternal UPD was found in five patients (17%). The total Holm's score was 10.7 ± 2.0 with a major criteria of 7.2 ± 1.2. The SDS values of height, weight, and BMI were −0.96 ± 1.29, 2.28 ± 2.66, and 3.14 ± 2.74, respectively. The body fat percentage, total body water, and soft lean mass were 45.9 ± 10.8%, 36.6 ± 7.3%, and 49.9 ± 9.9%, respectively. The fat distribution, calculated using the waist–hip ratios of females and males, were 0.99 ± 0.13 and 1.03 ± 0.13, respectively. The body fat percentage was positively correlated with the SDS for weight ($r = 0.581$, $p < 0.01$), SDS for BMI ($r = 0.665$, $p < 0.01$) (Fig. 1) and waist-hip ratio ($r = 0.431$, $p < 0.05$) and negatively correlated with the total body water percentage ($r = -0.997$, $p < 0.001$) and soft lean mass percentage

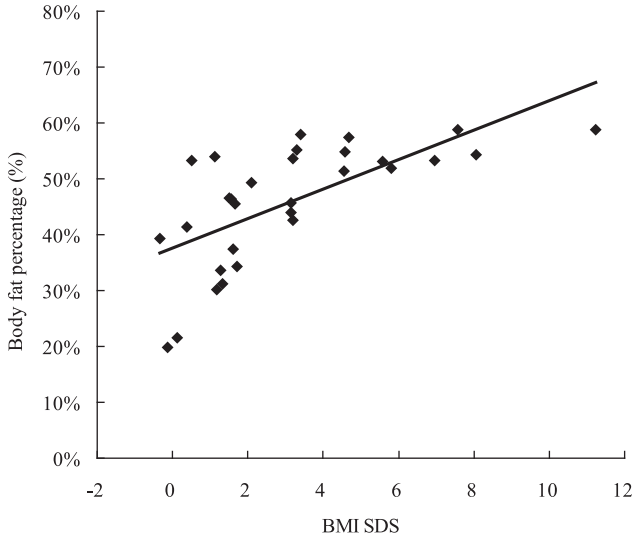

Figure 1 Body mass index (BMI) and standard deviation scores (SDS) for body fat percentage of 30 patients with Prader-Willi syndrome. Increased body fat percentage was associated with an increased BMI SDS ($r = 0.665$, $p < 0.01$).

($r = -0.996$, $p < 0.001$). There were no significant correlations between gender or genotype pattern (deletion vs. UPD) and the BIA results.

Baseline and follow-up BIA were performed on the five patients who had received growth hormone therapy. These patients received growth hormone therapy for periods ranging from 1.5 to 4.6 years. In each case, treatment resulted in reduced weight, BMI SDS, and body fat percentage, as well as increased percentages of total body water, soft lean mass, and fat-free mass. The percentages of body fat, total body water, soft lean mass, and fat-free mass were significantly different after receiving growth hormone therapy ($p < 0.05$). However, due to the small sample size, there were no statistically significant differences in weight or BMI SDSs ($p > 0.05$) (Table 1).

Compared with the published reference values for normal Chinese children,[11] patients with PWS had a higher percentage of body fat as determined by BIA. This was true for both genders and all age groups (Fig. 2). Based on the percentage of body fat, 93% (28/30) of our study subjects were considered obese ($> 95^{th}$ percentile).

Discussion

Patients with PWS had significantly higher body fat percentages, as measured by BIA, compared with those of normal children.[11] These patients were also shorter, heavier, and had higher BMIs.[16] BMI is the most widely used anthropometric index of obesity, even though both local and international reference standards are also available.[16,17] However, BMI is just an index, not a measurement, and it does not distinguish between increased mass in the form of fat, bone, or lean tissue; thus, the use of BMI may lead to the misclassification of some patients. As explained above, DXA's expense and complexity limit its usefulness in routine clinical settings. It has, however, been used in several investigations on untreated patients with PWS.[5,7,8] The percentages of body fat reported in those studies ranged from 42.6 to 47.4% (Table 2), similar to the results presented here calculated using BIA. Although we did not perform a head-to-head study of these two methods, our findings suggest that BIA is a less expensive and readily available method that is reasonably accurate.

Similar comparisons have been made between the segmental multifrequency bioelectrical impedance analyzer used in this study (InBody 3.0) and DXA.[12,13] The values for fat mass, fat-free mass, and body fat percentage derived using either technique correlate well with each other. Additionally, our results are similar to those reported by Davies et al,[9] who used single-frequency BIA, and Shu et al,[10] who used the same InBody system as that used in this study (Table 2). Shu et al[10] also reported nine patients who had been treated with growth hormone who were subsequently reported to have a mean body fat percentage

Table 1 Baseline and follow-up bioelectrical impedance analysis of five patients with Prader-Willi syndrome who were treated with growth hormone therapy for 1.5—4.6 years.

Gender	Genotype pattern	BIA	Age at BIA (y)	GH therapy duration (y)	Weight SDS	BMI SDS	TBW percentage (%)	Soft lean mass percentage (%)	Body fat percentage (%)	FFM percentage (%)
M	Del	Baseline	3.6	4.1	4.78	4.67	27.8%	38.3%	57.4%	42.6%
		Follow-up	7.7		0.11	0.12	54.5%	70.9%	23.1%	76.9%
M	Del	Baseline	6.1	4.6	1.76	3.14	37.6%	51.5%	44.0%	56.0%
		Follow-up	10.7		1.53	1.97	38.7%	52.8%	43.7%	56.3%
F	Del	Baseline	7.0	1.6	−0.51	1.13	30.3%	41.2%	54.0%	46.0%
		Follow-up	8.6		−0.85	0.37	45.5%	61.9%	32.5%	67.5%
M	UPD	Baseline	7.6	1.5	−0.57	0.51	30.7%	42.0%	53.4%	46.6%
		Follow-up	9.1		−0.63	−0.44	42.5%	57.5%	37.1%	62.9%
M	Del	Baseline	10.6	1.5	−0.75	0.37	39.7%	54.2%	41.3%	58.7%
		Follow-up	12.1		−1.12	−0.57	41.6%	56.8%	38.7%	61.3%
p-value					0.360	0.117	0.013	0.011	0.012	0.012

BMI, body mass index; Del, deletion; FFM, fat-free mass; GH, growth hormone; UPD, uniparental disomy; SDS, standard deviation score; TBW, total body water.

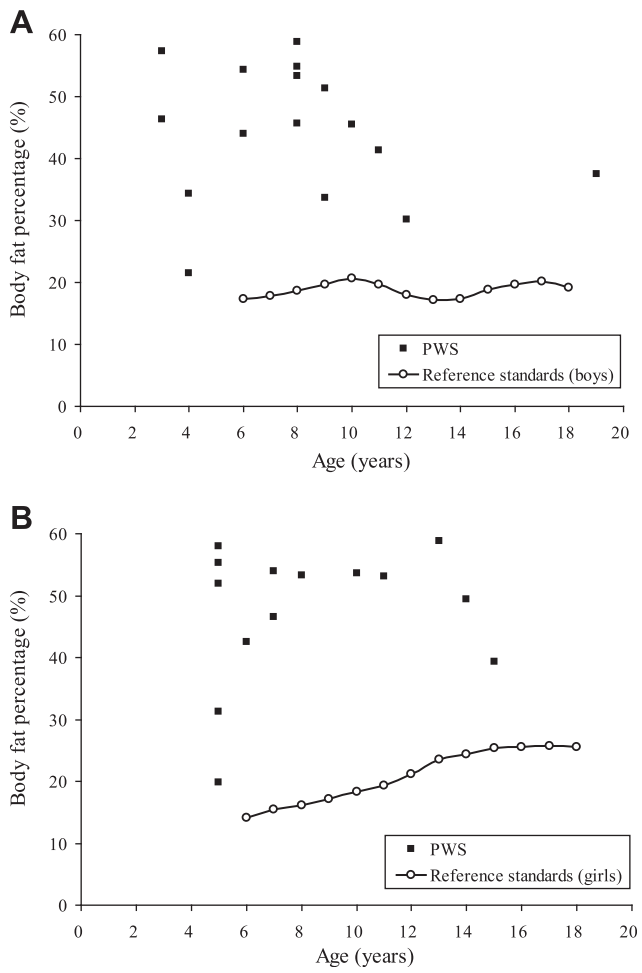

Figure 2 Body fat percentages of 30 patients with Prader-Willi syndrome (PWS) compared with the reference values for normal Chinese children. (A) Boys; (B) girls.

of 34.0 ± 9.8%. They did not, however, report the baseline data for these nine patients. We, however, did compare baseline and posttreatment values measured in the five patients who received growth hormone. As expected, they demonstrated reductions in their body fat percentages, a result that was confirmed using repeated BIA measurements.

Table 2 Comparison of published body fat percentages using dual-energy X-ray absorptiometry or bioelectrical impedance analysis for patients with Prader-Will syndrome not treated with growth hormone therapy.

References	Year	Method	n	Age (y)	Body fat (%)
Brambilla et al[5]	1997	DXA	27	6—22	47.4 ± 7.2
Carrel et al[8]	1999	DXA	19	4—16	42.6 ± 8.1
			35		46.3 ± 8.4
Höybye et al[7]	2003	DXA	19	17—37	45.2 ± 4.0
Davies et al[9]	1992	BIA	14	2.9—16.0	42.0 ± 10.7
Shu et al[10]	2007	BIA	11	8.6—23.3	44.3 ± 9.0
Present study	2010	BIA	30	2.9—19.6	45.9 ± 10.8

BIA, bioelectrical impedance analysis; DXA, dual-energy X-ray absorptiometry.

We found no significant differences between gender or genotype and the BIA results. To the best of our knowledge, this is the first evidence that the genotype itself does not significantly affect the body composition values that are measured by BIA. However, this study consisted of a small number of patients. It would be worthwhile to address this question using a larger group of patients.

The waist—hip ratio is the most widely used method for evaluating abdominal fat distribution, with suggested cut-off values of 0.80—0.90 for females and 0.94—1.00 for males.[18] In this study, 71% (10/14) of females and 50% (8/16) of males had ratios above the cut-off values, suggesting a high prevalence of abdominal obesity. Again, this finding is expected in patients with PWS.

This study was limited in that it was unable to control. We did not compare the BIA results to other methods that can be used to assess body composition, nor did we simultaneously examine a control group of normal subjects using the same technique. However, to the best of our knowledge, this is the first study that used BIA to assess patients with PWS, both before and after growth hormone therapy. Previous studies have shown that growth hormone therapy improves both the growth rate and body composition of patients with PWS.[19,20] Growth hormone therapy has been endorsed by the National Health Insurance for the treatment of PWS in Taiwan since May 2004. Since BIA is a rapid, painless, and noninvasive method for evaluating body composition,[6,11—13] we urge the consideration of its use for managing patients with PWS.

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