Correlation of Serum Leptin Level with Bone Mineral Density and Bone Turnover Markers in Chinese Adolescent Dancers[1]

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Objective To investigate plasma leptin concentrations in adolescent female dancers and to determine whether leptin has some effects on their bone mineral density (BMD) and bone turnover markers. **Methods** Sixty dancers aged 15-17 years and 77 healthy controls were enrolled in the study. Bone mineral density (BMD) and body composition were detected by dual energy X-ray absorptiometry. Serum leptin concentrations were measured by radioimmunoassay (RIA). Two bone turnover markers, bone-specific alkaline phosphatase (BAP) and tartrate-resistant acid phosphatase(TRACP), were determined by ELISA. **Results** The dancers had a lower fat mass and a lower leptin level than the controls, while they had a relatively higher BMD of the total body and legs after adjustment for BMI and age. The levels of bone resorption and formation of markers were higher in the dancers than in the controls. Leptin was positively correlated with BMI, body weight, fat mass, and percentage of body fat. In dancers, Leptin was positively correlated with the BMD of the total body and the left leg. However, after adjustment for BMI, no correlation of serum leptin concentrations with BMD values was found in either dancers or controls. Nor correlation was found between leptin and bone turnover markers after adjustment for BMI. **Conclusion** The leptin profile is different between the controls and the dancers with a lower BMI and a lower fat mass. Circulating plasma leptin level depends on BMI and is not a direct determinant of BMD in Chinese adolescent dancers.

Key words: Leptin; Bone mineral density; Bone turnover marker; Adolescent dancer; China

INTRODUCTION

Leptin, encoded by the so-called obesity (ob) gene, is synthesized and secreted by adipocytes. Obesity is usually a protective factor for osteoporosis, with an increased bone mineral density (BMD) and plasma leptin concentration[1-2]. It has been shown that the effect of fat mass on BMD may be mediated by hormonal factors, such as sex hormone, leptin, and insulin, and that low body weight is a risk factor for the fracture of proximal femur and vertebrae, accompanied with a low plasma leptin concentration[3-4]. The plasma leptin concentration is correlated with body fat content, increases in obesity and decreases in anorexia nervosa[1,5].

Since girls engaged in dancing usually have a lower BMI and a lower fat mass, they are thus believed at a greater risk for disordered eating, irregular menarche and osteoporosis[6]. Loss of bone mineral density can be devastating for adolescent girls and may never be regained. Serum leptin seems to play a major role in disordered eating, irregular menarche, and osteoporosis of young female rhythmic gymnasts[7-8].

At present, the relationship between serum leptin concentration and BMD is unclear. Since dancing is a demanding discipline involving factors that have a positive (weight-bearing exercise) or a negative (malnutrition, low body mass, and fat-free weight, hormonal imbalance) effect on BMD, this study was to investigate the leptin level in dancers in order to have a further understanding of its influence on their bone health status.

MATERIALS AND METHODS

Subjects

Sixty dancers aged 15-17 years from Beijing

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Secondary Dance School affiliated to Beijing Dance Academy and 77 age-matched healthy controls from Beijing Jinsong Vocational School were enrolled in the study. Subjects with a medical condition or on treatment which were potentially able to influence BMD were excluded from the study.

All the subjects gave their informed consent to participate in this study. The study was approved by the Ethical Committee of Nutrition and Food Safety Institute, Chinese Center for Diseases Control and Prevention.

Methods

Body weight and height were measured by a nurse practitioner. Pubertal development was self-evaluated by the participants themselves using a Tanner scale.

Venous blood (5 mL) was obtained and analyzed for leptin level and biochemical markers of bone turnover. Leptin level was measured using a radioimmunoassay (RIA) kit (Beijing North Institute of Biological Technology). Bone turnover markers, serum bone-specific alkaline phosphatase (BAP) and tartrate-resistant acid phosphatase (TRACP)-5b were detected using an ELISA kit (IDS Ltd, UK).

The bone density and body composition of all subjects were detected by the health professionals in Beijing No. 304 Hospital with a dual energy X-ray absorptiometer (DXEA). The coefficient of variation in repeated measurements was less than 1%. Bone mineral status was assessed by areal BMD (g/cm^2) and BMC (g). Body composition was evaluated by fat mass (g) and percentage of body fat (FAT %).

Statistical Analysis

Normally distributed data were expressed as $\bar{x} \pm s$. Independent sample *t*-test was used to calculate differences in means. Pearson correlation coefficient was used to determine the correlation between leptin and supposed factors. Partial correlation was tested between two variables independently of a covariate. Statistical analyses were performed using SPSS 11.5 software. $P<0.05$ was considered statistically significant.

RESULTS

Subjects

Descriptive characteristics of the subjects are presented in Table 1. No difference was observed in age between the two groups. In this study, the dancers had a lower BMI and a lower body fat mass due to their low dietary energy intake and high energy expenditure than the controls, and their age at menarche was also older than the controls.

TABLE 1

Descriptive Data about the Controls and the Dancers ($\bar{x} \pm s$)

	Controls (*n*=77)	Dancers (*n*=60)
Age (Years)	16.4±0.6	16.5±0.7
Height (cm)	159.1±5.9	163.5±4.3[a]
Weight (kg)	55.0±8.8	48. 9±4. 8[a]
BMI (kg/m^2)	21.7±3.1	18.3±1.4[a]
Fat Mass (g)	19042.71±4620.36	12047.84±2945.45
Dietary Energy Intake (Kcal/d)	2614.73±543.79	1792.55±430.22[a]
Energy Expenditure (Kcal/d)	1287.25±219.98	1480.42±223.62[a]
Energy Balance (Kcal)	1280.58±658.0	304.21±47.93[b]
Age at Menarche (Years)	13.00±1.25	13.98±0.92[a]

Note. [a]$P<0.05$, [b]$P<0.01$ *vs* control group.

Bone Measurement

The bone characteristics of the subjects in our study are listed in Table 2. Compared to the controls, BMD and BMC of the total body and legs in the dancers were significantly increased after adjustment for BMI and age ($P<0.05$). No difference was observed in the BMD of arms and forearms, and the BMD of arms and distal left forearm in the dancers was even higher in the controls ($P>0.05$).

Biochemical Measurement

The plasma leptin concentration was significantly lower in the dancers than in the controls, and the levels of leptin, BAP, and Tracp-5b were significantly higher in the former than in the latter after adjustment for BMI (Table 3).

TABLE 2

BMD and BMC Measurements in the Controls and the Dancers ($\bar{x} \pm s$)

Sites of Measurement	Controls (n=77)	Dancers (n=60)
Total Body BMD (g.cm^{-2})	0.872 ±0.006	0.92 ±0.007 [a]
Total Body BMC (g)	2221.37 ±25.39	2396.95 ±30.85[b]
Left Leg BMD (g.cm^{-2})	0.901 ±0.008	0.965 ±0.009 [a]
Left Leg BMC (g)	382.34 ±5.66	442.21 ±6.87[b]
Left Arm BMD (g.cm^{-2})	0.519 ±0.007	0.511 ±0.007
Left Arm BMC (g)	132.95 ±2.42	127.97 ±1.99
Distal of Left Forearm BMD (g.cm^{-2})	1.198 ±0.0024	1.185 ±0.026

Note. [a]$P<0.05$, [b]$P<0.01$ *vs* control group.

TABLE 3

Biochemical Characteristics of the Controls and the Dancers ($\bar{x} \pm s$)

	Controls (n=77)	Dancers (n=60)
BAP (ng/mL)	24.69 ±11.21	41.57 ±25.75[b]
TRACP (ng/mL)	3.25 ±1.02	5.68 ±3.06 [b]
Leptin (ng/mL)	5.28 ±2.48	2.51 ±1.96 [b]
Leptin-BMI-adjusted (ng/mL)	4.38 ±0.25	3.52 ±0.26 [a]

Note. [a]$P<0.05$, [b]$P<0.01$ *vs* control group.

Correlation between Serum Leptin Concentration and Other Indices

BMI, body weight, and fat were positively correlated with the leptin level in the two groups (Table 4). The correlation (r) between leptin and BMI, total body fat, and body weight was 0.724, 0.729, and 0.623, respectively ($P<0.01$). Serum leptin concentration was not correlated with body height.

TABLE 4

Correlation between Variables and Serum Leptin Levels in the Controls and Dancers

	Dancers		Controls	
	R	*R* Value Adjusted for BMI	R	*R* Value Adjusted for BMI
BMI	0.523**	/	0.697**	/
FAT (%)	0.531**	0.454	0.472**	0.189
Fat Mass (g)	0.579**	0.464	0.622**	0.193
Weight	0.341**	0.019	0.617**	-0.002
Height	0.034	0.008	0.005	0.015
Whole Body BMD (g/cm^2)	0.302*	0.09	0.526**	0.127
Left Leg BMD	0.259*	0.044	0.473**	0.076
Right Leg BMD	0.065	-0.128	0.484**	0.120
Left Arm BMD	0.229	0.098	0.397**	0.042
Right Arm BMD	0.185	0.058	0.410**	0.0004
Distal of Left Forearm BMD	0.219	0.039	0.380**	0.098
BAP	0.044	-0.015	0.021	0.102
TRACP	-0.021	0.039	-0.249*	-0.209

Note. *$P<0.05$, **$P<0.01$ *vs* control group.

The BMD of the whole body and the left leg was positively correlated with the serum leptin level in the dancers ($P<0.05$). The leptin level was significantly correlated with the BMD of the whole body, legs, arms, and distal left forearm in the controls ($P<0.01$). However, after adjustment for BMI, no correlation was observed between serum leptin concentration and BMD in the two groups.

In addition, no correlation was found between serum leptin level and BAP and TRACP after adjustment for BMI.

DISCUSSION

Leptin plays an important role in the regulation of food intake, energy expenditure, and body weight[9]. In this study, the serum leptin concentration was closely correlated with body weight, BMI, and body composition, which is consistent with previous findings[7, 10-11]. The fat mass and serum leptin level were significantly lower in the dancers before and after adjustment for BMI, which are consistent with those observed in anorexia nervosa syndrome[12]. Contrary to anorectic subjects, hypoleptinemia did not affect the bone health of these dancers who had a relatively higher BMC and BMD after adjustment for BMI and age, which is consistent with the reported findings[7].

Low serum leptin concentration is a phenomenon observed in sportsmen/sportswomen and its explanation remains controversial. The cause of such a decline is not only due to the simply decreased total body fat content[13], but also due to its mechanism linked to a neurohormonal adaptation to the long-term physical training[14]. In our study, insufficient calorie intake coupled with high calorie expenditure in exercise training resulted in sustained low energy availability. It has been shown that interaction of exercise, energy balance, and systemic leptin occurs in human beings[15]. There is also evidence that energy imbalance can regulate leptin secretion, independently from the body fat reserves[16].

In our study, both BAP and TRACP-5b were higher in the dancers than in the controls. This greater rate for bone remodeling associated with a positive uncoupling index may partially explain why the bone mass and density were higher in the dancers. Munoz *et al.*[17] reported that serum leptin level is a good bone mass marker. The decreased bone mass observed in their subjects could be explained, in part, by the increased bone resorption with no increased bone formation. However, the correlation between leptin and bone turnover markers appears complex because leptin may exert a protective effect on bones by limiting excessive bone resorption and bone formation associated with bone loss in postmenopausal women[18]. In the present study, BAP and TRACP were not correlated with serum leptin before and after adjustment for BMI, thus confirming the lack of any relationship between bone turnover and leptin concentration, which is consistent with the reported data[19-20].

In this study, serum leptin level was not correlated with BMD. However, it has been reported that serum leptin level is inversely related with BMD[21-22], while other studies[23-24] have shown that serum leptin level is positively correlated with BMD. In our study, after adjustment for BMI or fat mass, no correlation was found between leptin and BMD, indicating that leptin level failed to influence bone mass independently of adiposity, which is in agreement with the reported findings[19, 25].

In conclusion, energy imbalance can regulate leptin secretion, and serum leptin concentration depends on BMI and is not a direct determinant of BMD in Chinese adolescent girls. The precise cause of such a phenomenon is unknown.

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