論　文

Relationship between Shapes, Percentage of Body Fat, Living History and Calcaneus Bone Strength in Female University Students

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Key words：Living history, Calcaneus bone strength, Female university students

Ⅰ. Introduction

In recent years when the declining birth rate and growing proportion of the elderly are developed, a rapid increase of osteoporosis has become a social problem. The active level in the daily living, exercise habits[1-3], eating habits[4-6], shapes (height and weight)[7,8], percentage of body fat and body fat mass[9,10], menses state[11,12], smoking[13], drinking[3], stress[14], heredity[5,15] and autonomic nerve system activity[16] etc. have an influence on the onset of osteoporosis. Early detection and settlement are primary prevention for osteoporosis. Furthermore, it is thought to be necessary for people to measure the bone strength and make efforts to increase it in the time of youth[3,17].

When they are university students, many students get away from their parents, and it is predicted that a little disorder is occurring to regular living habits (especially eating habits) relatively. It is guessed that a change in these living habits has in some degree influenced the bone strength. The present study's author investigated the relationship between calcaneus bone strength and shape, percentage of body fat and living history of male university students in the previous study[18]. The purpose of this study is, from the same point of view, to investigate the relationship between calcaneus bone strength and shape, percentage of body fat and living history of female university students.

Ⅱ. Methods

A.Subjects

A total of 117 female university students of 1st grader (n=59) and 2nd grader (n=58) participated in this study as a subject. Their age is 19.7±0.7 years old (mean±standard deviation, it is the same in the following).

B. Measurements and survey items

The shapes (height and weight), percentage of body fat (measured by TBF-300 made by TANITA CORPORATION) and calcaneus bone strength (measured by ultrasonic bone assessment equipment AOS-100 made by Hitachi Aloka Medical,Ltd. and the right calcaneus bone was measured.) were measured and the life situation (method of going to school, exercise habits in the past and present, bone fracture experience, eating habits, smoking habits and the alcohol absorption situation, etc.), the manifested age of menarche, and the situation of the present menses were investigated by using the interview sheets.

Osteo sono-assessment index (OSI) that was calculated in $TI \times SOS^2$,in which SOS was speed of sound (SOS) and TI was transmission index when the ultra sound penetrated through the calcaneus bone, was evaluated as the bone strength.

The absorption number of times a week was investigated about the absorption situation of the dairy products (milk and yogurt), fish, brightly colored vegetables, fermented soybeans, tofu, canned juice, sweet drink, sweet snack, sweet roll, instant food (instant noodles in a cup and retort food,

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etc.), fast food (hamburgers and fried chickens, etc.) and breakfast as the eating habits, and each item was quantified in 4 stages available for the bone strength (then 36 points in total). The value of OSI in this paper was the one divided by 10^6.

C. Statistical analysis

The mean values were assessed by non-paired t-test and if F-ratio had been significant, then Welch's test was adopted instead of it. Pearson's product-moment correlation coefficient was used. A p value of less than 0.05 was considered statistically significant.

Ⅲ.Results

Height, weight,and percentage of body fat were 157.0±6.7 cm ,55.9±11.5 kg,and 30.2±7.3 % in the 1st grader and 157.2±5.5 cm, 52.1±5.9 kg, and 27.0±4.9 % in the 2nd grader respectively. Each OSI was 2.953±0.350 and 2.860 ±0.313 respectively by the order of the 1st grader and 2nd grader, and the 1st grader was slightly higher, but there was no significant difference in them.

While the correlation coefficients of the bone strength with height, weight, BMI, percentage of body fat, and lean body mass were 0.563 ($p<0.01$), 0.479 ($p<0.01$), 0.290 ($p<0.05$), 0.006 (NS) and 0.644 ($p<0.01$) in the 1st grader, those of 2nd grader were –0.175 (NS), 0.231 (NS), 0.387 ($p<0.05$), 0.173 (NS) and 0.187 (NS) respectively. In the combined group of both graders, the correlation coefficients were 0.247 ($p<0.01$), 0.406 ($p<0.01$), 0.336 ($p<0.01$), 0.101 (NS), and 0.483 ($p<0.01$) in the same above-mentioned order respectively.

OSI (3.012±0.392, n=25) of the students who went to school by car, bus or motorcycle was slightly but not significantly higher than that (2.878±0.313, n=92) of the students who went to school on foot or by bicycle. On the other hand, the weight of the former (58.3±11.8 kg) was significantly ($p<0.05$) heavier than that of the latter (52.9±8.2 kg). Similarly, OSI (2.919±0.352, n=12) of the students who went to school by car, bus and motorcycle was slightly but not significantly higher than that (2.816±0.303, n=56) of the students who went to school on foot or by bicycle in the students who do not presently exercise, too. The weight of the former (57.5±14.8 kg) was heavier than that of the latter (50.8±5.9kg), but not significantly.

OSI of the students who belonged to an athletic club in the university and were active for more than 2 hours a week (athletic club one) was significantly higher than that of the students who did not take regularly exercise and belonged to a cultural club (non-athletic club one) (Figure 1).

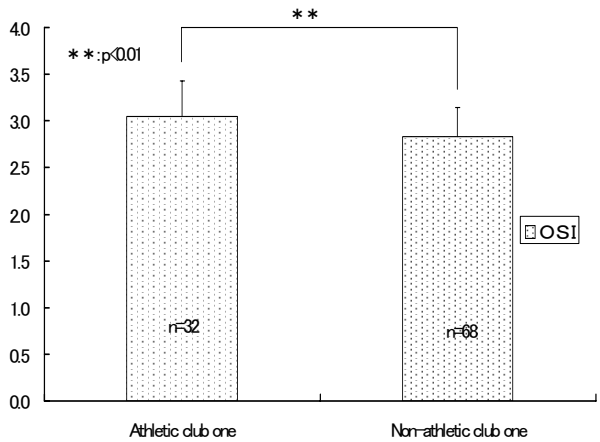

Figure 1. Comparison of OSI of athletic club one with non-athletic club one.

Height, weight, BMI and lean body mass of the former were significantly bigger than those of the latter (the former vs. the latter: height; 159.4 ± 7.2 cm vs. 156.1 ± 5.3 cm ,$p<0.05$, weight; 58.8±10.6 kg vs. 52.0±8.5 kg , $p<0.001$, BMI; 23.1 ± 3.4 kg/m^2 vs. 21.3 ± 3.3, kg/m^2 ,$p<0.05$ and lean body free mass; 41.4±6.6kg vs. 36.8±2.8 kg ,$p<0.001$).

OSI (3.172±0.434, n=17) of the students who belonged to athletic club at present and had been active in an athletic club in the junior high school and the high school age was slightly but not significantly higher than that (2.925±0.347, n=21) of the students who did not belong to athletic club at

present but had been active in athletic club in above-mentioned age.

The sports events which were performed by athletic club one were dance, volleyball, basketball, archery, swimming, and golf.

When compared OSI by the presence of experience of the bone fracture in the past, there was no difference between OSI (2.972±0.397, n=23) of bone fracture experienced students and the that (2.891±0.317, n=94) of bone fracture inexperienced students.

The eating habits score was divided into two groups of less than 24 points (n=71) and more than 25 points (n=46), and OSI was compared on eating habits scores. There was no significant difference in OSI between the students of less than 24 points (2.904±0.340) and the students more than 25 points(2.910±0.329). But, OSI (3.006±0.403, n=36) of the students who hardly eat instant foods tended to be higher than that (2.863±0.290, n=81) of the students who eat them more than several times a week.

With regard to smoking habits, OSI (2.904±0.331, n=110) of the nonsmokers was slightly lower than that (2.942±0.402, n=7) of the smokers. But, one student out of the smokers was 97.0 kg of weight and OSI was 3.229, and another student was a former top athlete who was doing long jump of athletics at junior high school and high school, and OSI was 3.652, and they were said to be special examples. OSI of the other 5 smokers was 2.742±0.215, and it was slightly lower than that of the nonsmokers.

With regard to drinking habits, OSI (2.944±0.353, n=66) of the students who do not drink alcohol at all was slightly but not significantly higher than that (2.859±0.304, n=51) of the students who drink from several times a month to several times a week.

Almost no difference was found in OSI between the students whose menarche were manifested in the time from 4th grade to 6th grade of elementary school (2.904±0.321, n=65) and the students whose menarche were manifested in the time from the 1st grade of junior high school to 1st grade of high school (2.910±0.352, n=52) .

With regard to menstruation, no significant difference was found in OSI between the students whose menstrual cycle was normal{ 2.917±0.322, n=85 (only the students who could be made confirmation) } and the students whose menstrual cycle was abnormal (2.919±0.558, n=9, the oligomenorrhea students), too. But 2 students out of the students whose menstrual cycle were abnormal were elite athletes who had done volleyball for more than 4 days a week up to now from junior high school age, and OSI were very high, being 3.912 and 3.801. OSI of the other 7 students was significantly lower than that of the normal menstrual cycle students (Figure 2).

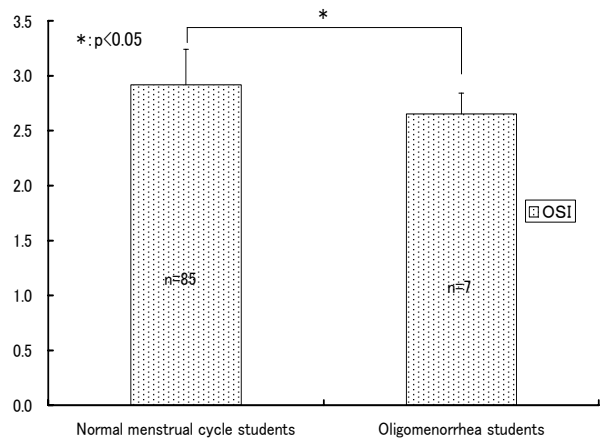

Figure 2 Comparison of OSI of notmal menstrual cycle students and oligomenorrhea students

Ⅳ.Discussion

The patients of osteoporosis including pre-osteoporotic stages are said to be more than 11,000,000 people at present. For the prevention from the onset of the osteoporosis, early detection and treatment is needed and more important is how to raise the bone mass at the time of youth (from the time of elementary school to university).

It has been reported widely that bone mass relates to the shapes and percentage of body fat closely[7,8,19]. Piezoelec-

tricity occurs to a bone by taking the load, and a calcium ion gets fixed there as it may be explained in detail at below-mentioned place of physical exercise, so that a close relationship between the bone mass and the weight in particular exists.

When observed the relationship between height, weight, BMI, lean body mass and OSI in the 1st grader, and the relationship between BMI and OSI in the 2nd grader, the significant correlation coefficients were admitted. These results were completely different from the previous study results[18] which were drawn from male university students of the same generation.

The relationship between calcaneus bone strength and shape in female university students was suggested to be closer conspicuously than that of male university students, but the causes were not clear. On the other hand, since the production of estrogen is closely associated with the body fat in females[20], the percentage of the body fat is reported to relate closely with the bone mass. But in this study the 1st grader and 2nd grader could not admit the significant correlation coefficients between OSI and percentage of the body fat. The cause can't be elucidated in detail about this phenomenon, but the fact that serum leptin which is a fat related hormone is correlated positively with the percentage of body fat is adjusting to bone formation and resorption variously and simultaneously[16]is possibly related to that.

It has been often reported that physical exercise and training enhance the bone strength[1-3,11,21-24]. It was thought that this matter depended on the reasons that piezoelectric occurred to the loaded bone by physical exercise, so calcium ion got fixed there, its healing mechanism worked in regard to the minute bone fracture (micro crack) produced by the exercise load, and bone metabolism was activated along with the increase of the blood flow into the bone by the exercise.

In this study OSI of the athletic club one was significantly higher than that of non-athletic club one, and OSI of the students who had been active in athletic club from the time of junior high school to the present tended to be higher than that of the students who had been active in athletic club but not at present, which suggested the importance of continuing physical exercise from the time of junior high school for the development of bone strength.

However, the significantly heavier weight and lean body mass of the athletic club one than those of non-athletic club one, which were a result of having done exercise training, contributed to the significantly higher OSI of the former.

Furthermore, the bone strength is influenced by the types of the exercise events. It was demonstrated that the bone strength of the students engaged in the weight-bearing types of sports was stronger than that of the students engaged in the non-weight-bearing types of sports[25]. In the present study no significant difference in bone strength was shown among the exercise events possibly due to the insufficient number of the subjects. Consequently, additional refined study focusing on the types of the exercise events will have to be conducted with much more subjects.

OSI of the students who went to school by car, bus or motorcycle was slightly higher than that of the students who went to school on foot or by bicycle, which possibly resulted from the heavier weight of the former than that of the latter. This was the same in the case of the students who took exercise regularly, indicating that in this study for female university students activity level of the daily living had no influence on the bone strength. From these results, further study with the identified weight group is needed.

There was no close relationship between the bone strength and the presence of the bone fracture in the past in this study. While some studies[26-28] showed the close relationship between the bone strength and the bone fracture, the other[29] reported contradictory results. It is considered that besides the bone property the cause of the bone fracture depends on the various situations such as impossible movement,

extremely high level of activity and so on, so that further detailed study investigating the relationship between the bone fracture and physical activity situation will be needed.

It is thought that there are close relationship of the bone strength with the absorption rate of protein, calcium, magnesium, phosphorus, vitamin C, vitamin D, vitamin K, sugar, absorption ratio of calcium and phosphorus (1:1-1:2 is ideal), absorption ratio of calcium and magnesium (2:1 is ideal) and presence of breakfast absorption[4-6,30,31)]

Most students got away from their parents and were boarding in this study, and it was predicted that eating habits were more unstable than their high school age. But after eating habits investigation was performed in relation to the above-mentioned matters, it was impossible to admit a significant difference in the calcaneus bone strength between the low dietary points students and high dietary points students. But the students who refrained from eating the instant foods full of phosphorus tended to have higher bone strength, which suggested that in the boarding life eating instant foods excessively should be avoided

It was considered that since smoking decreased estrogen secretion[32)] and drinking increase serum cortisol[33)] and urinary excretion amount of calcium and magnesium[34)], smoking and drinking habits were thought to have a negative influence on the bone strength (increased serum cortisol results in the enhancement of the bone absorption as well as the decline of the bone formation[35-37)]). But in this study with the students of 20 years or less, smoking and drinking habits seemed to have no significant influence on their bone strength.

Moreover, it was also reported that early menarche enhanced the bone strength [6)], but in this study the manifested time of the menarche made no difference in the bone strength. In addition, since the estrogen suppresses the bone resorption[38)], the abnormal menstrual cycle weakens the bone strength. So in this study abnormal menstrual cycle students except two elite athletes showed significantly lower bone strength than normal menstrual cycle students. However, in this study, the cause of the abnormal menstrual cycle was not elucidated, so it was considered that the mental stress induced by the problem of daily living, the excessive dietary restriction and so on were main causes, so that the control or elimination of the above-mentioned factors were suggested to be very important for the female university students.

Furthermore, it was guessed that the reason why the 2 elite athletes had very high bone strength despite the abnormal menstrual cycle was attributed to the balance of combined results of the estrogen deficiency and physical exercises.

In conclusion, it was emphasized that calcaneus bone strength of female university students was correlated significantly with their anthropometric measures, and was much influenced by the exercise habits at present or from the past.

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女子大学生における形態・体脂肪率および生活履歴と踵骨骨強度との関連性

岡野亮介

要旨：本研究の目的は、女子大学生における、踵骨骨強度と形態・体脂肪率および生活履歴との関連性を追究することである。本研究の被検者は女子大学生 1・2 年生計 117 名（年齢は 19.7±0.7 歳）であった。踵骨骨強度と身長、体重、BMI 及び除脂肪体重との間に有意な正の相関が認められた。踵骨骨強度は、現在運動を行っている学生の方が運動を行っていない学生より有意に高い値を示した。また、踵骨骨強度は月経正常者と比較して、エリートスポーツ選手を除いた月経異常者では、有意に低かった。従って、女子大学生においても身体運動を習慣的に行い筋肉量が多く、また正常な月経状態であることが骨強度の維持・向上に有利であることが確認された。一方、踵骨骨強度と過去における骨折の経験の有無との間には密接な関連は認められなかった。さらに、踵骨骨強度と食習慣、飲酒および喫煙との間にも密接な関連性は認められなかった。これらの点については今後さらに追究していく必要があろう。