



Research Article

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Calcaneal Bone Status in Elite Karate Practitioners

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Abstract

Objective: Traditional Japanese karate tournament consists of kata (forms) and sparring competitions. The purpose of this study was to compare calcaneal bone status between highly competitive sparring and kata practitioners who were members of the national team.

Methods: The subjects were 26 men and 20 women karate practitioners and were divided into 4 groups: 16 men's sparring (M-Spar), 10 men's kata (M-Kata), 12 women's sparring (W-Spar) and 8 women's kata practitioners (W-Kata). Quantitative ultrasound measurements of the right calcaneus were performed to measure speed of sound (SOS), which was compared with the percentage of the young adult mean (%YAM). Nutrient intake was assessed with a food frequency questionnaire. Analyses were performed separately for men and women practitioners.

Results: There were no significant differences in body mass index, calcium, vitamin D and vitamin K intakes between the M-Spar and M-Kata or W-Spar and W-Kata. The M-Spar showed significantly higher SOS and the percentage of the young adult mean (%YAM) than the M-Kata. Likewise, the W-Spar showed significantly higher SOS and %YAM than the W-Kata. %YAM in both M-Kata and W-Kata were very close to 100% YAM.

Conclusion: Practicing karate, especially sparring techniques, give positive effects on calcaneal bone status.

Keywords

Quantitative ultrasound; Calcaneal bone status; Calcium; Vitamin D; Vitamin K; Karate, skeleton

Background

Karate is one of the most popular martial arts practiced both inside and outside of Japan. Traditional karate training consists of the practice of basic techniques, kata and sparring. The basic techniques such as punching, kicking, blocking and striking are practiced either in the stationary position or with body movements in various formal stances. Kata are set forms in a pre-established sequence of defensive and offensive techniques and movements. Sparring is the execution of defensive and offensive techniques while one is freely moving against an opponent. In addition to the traditional karate training, many competitive practitioners cross train by undertaking strenuous running and weight training programs to increase endurance, muscle development and power.

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Traditional Japanese karate tournament consists of kata and sparring competitions. There are distinct differences between kata and sparring competitions. No physical contact is produced in kata as opposite to sparring in which physical contact is produced. Thus, most injuries during karate tournaments occur during sparring competition.

The peak bone mass attained is an important protective factor against osteoporotic fractures in later life [1,2]. Several modifiable factors may help to preserve bone, among them body mass index (BMI) [3,4], nutrient intake [4-6], and physical activity [6,7]. It has been shown that athletes involved in sports that increase the mechanical stress placed on the bone (i.e., weight-bearing activities and/or strength training) have greater BMD than non-active control Group [8-12]. Andreoli et al. [13] reported that karate practitioners have significantly higher total BMD than age-matched untrained control Group. Drozdowska et al. [14] also reported that karate practitioners have significantly higher hand phalanges BMD than age- and body size-matched control Group. However, these 2 studies [13,14] used male subjects. Incidence of osteoporotic fractures is more frequent in women than in men [15,16]. To our knowledge, BMD in female karate practitioners have not been investigated. Furthermore, these 2 studies [13,14] have been undertaken in Western countries. The traditional Japanese dietary habits are characterized by lower intake of calcium than those of people living in Western countries [17]. Calcium, vitamin D and vitamin K intakes are key elements in promoting and maintenance of bone health and preventing bone loss [5,18].

When examining the effects of physical exercise on BMD, the bones in the foot are important region for evaluation, as they bear the greatest effects of gravity during exercise [19]. Quantitative ultrasound (QUS) is a portable and practical machine that measures bone status and involves no x-ray exposure [19]. To our knowledge, calcaneal bone status in karate practitioners has not been investigated. Furthermore, the above mentioned 2 studies [13,14] examined BMD of karate practitioners as a single group. Because high level sparring competitors have been reported to have a higher ability to accelerate the whole body than their kata counterparts [20,21] the mechanical stress placed on the calcaneus may possibly different between the sparring and kata practitioners. The purpose of this study was to compare calcaneal bone status between highly competitive sparring and kata practitioners.

Methods

Subjects and self-administered questionnaire

The study protocol was approved by the Ethics Committee of the University. Informed consent was obtained from each subject.

The subjects were 26 men and 20 women karate practitioners who were members of the Japanese national team. They were divided into 4 groups: 16 men's sparring (M-Spar) and 10 men's kata (M-Kata), 12 women's sparring (W-Spar) and 8 women's kata practitioners (W-Kata). These individuals competed in sparring or kata competition from April to December. Regional tournaments are held from April to July, and national, international, and/or world

tournaments are held from September to December. The members of the national team participated in a 3-day training camp once every month from May to September, so that all measurements and dietary information were obtained at the site of a training camp in June, which was considered representative of their physiological status during training for their next competition.

Information on karate training was obtained via a Self-reported questionnaire.

Measurements and dietary information

Weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively. BMI was calculated as $\text{weight}/\text{height}^2$ (kg/m^2). Percentage of body fat (%Fat), fat mass and lean body mass (LBM) were evaluated with the bioelectric impedance analyser (Inner Scan V, Tanita, Tokyo, Japan).

QUS measurements of the right calcaneus were performed (CM-100, Canon Lifecare Solutions Inc., Osaka, Japan). After cleaning the skin with ultrasound gel (Parker Laboratories, Inc., New Jersey, USA), the subject's heel was positioned in a small measurement device. The ultrasonic wave is transmitted through the heel and detected by a receiving transducer. Speed of sound (SOS) was measured using the device, which is the velocity of the ultrasonic wave as it passes through the heel and was compared with the percentage of the young adult mean (%YAM). The reproducibility of the QUS measurements was tested by repeating the measurements described above 3 times with repositioning on a group of 14 male and 14 female karate players. The coefficients of variation for men and women were 2.7 % and 3.0 % for SOS and 1.7% and 2.0 % for %YAM.

All subjects were interviewed by experienced dietitians using a food frequency questionnaire (FFQ), which is based on 29 food groups and 10 types of cooking, for estimating the energy and nutrient intakes of each subject during the past 1 to 2 months [22]. The FFQ was validated by a comparison with weighed dietary records for 7 continuous days [23]. From FFQ the mean daily intake of total energy and nutrients was calculated according to the Tables of the Japanese Foodstuff Composition [24]. Information on nutrient supplement and/or on diet was obtained via a self-administered questionnaire. The accuracy of the questionnaire was checked through individual interviews.

Analysis

The SPSS statistical software 22.0J (Chicago, IL) was used to analyze the data. Descriptive statistics included means and SD. Because sample size in each group was small, non-parametric statistics were used. Analyses were performed separately for men and women practitioners. The mean differences between M-Spar and M-Kata or between W-Spar and W-Kata were analyzed by Mann-Whitney U test. Pearson correlation coefficients were used to examine simple correlations between 2 variables. Two-sided $p < 0.05$ was considered to be statistically significant.

Results

The training status of karate practitioners is shown in Table 1. In addition to the traditional karate training, all karate practitioners cross trained by undertaking running and weight training programs.

The characteristics of the subjects are shown in Table 2. The M-Spar showed significantly higher height than the M-Kata. The W-Spar showed significantly higher LBM than the W-Kata.

Energy and selected micronutrient intakes of the subjects are shown in Table 3. There were no significant differences in energy and selected micronutrient intakes between the M-Spar and M-Kata or W-Spar and W-Kata.

SOS or %YAM did not significantly correlate with any variables shown in Table 2 and 3 (data not shown).

The SOS and %YAM of the subjects are shown in Figures 1 and 2, respectively. The M-Spar showed significantly higher SOS and %YAM than the M-Kata. Likewise, the W-Spar showed significantly higher SOS and %YAM than the W-Kata. %YAM in both M-Kata and W-Kata were very close to 100% YAM.

Discussion

It has been reported that body height, LBM, and BMI was positively associated with BMD [25-27]. In the present study, the M-Spar showed significantly higher body height than the M-Kata, while the W-Spar showed significantly higher LBM than the W-Kata. However, there were no significant differences in BMI between M-Spar and M-Kata or W-Spar and W-Kata. Furthermore, height, LBM, BMI and any of the nutrient intakes did not significantly correlate with SOS or %YAM. Calcium, vitamin D and vitamin K intakes are key elements in promoting and maintenance of bone health and preventing bone loss [5,18]. A poor intake of calcium increases fracture risk via low BMD [5], and a higher intake of calcium is associated with higher BMD [28]. The mean intakes of calcium in the M-Spar and M-Kata (561 ± 191 g and 683 ± 170 g, respectively) in the present study were much lower than the mean intake (1150 ± 75 g) of the highly competitive male karate practitioners reported from Western country by Andreoli et al. [13]. Although calcium intakes of W-Spar and W-Kata (940 ± 405 g and 846 ± 173 g, respectively) were lower than the values reported by Andreoli et al. [13], these values were well above the adequate dietary intake for Japanese [29]. When vitamin D is low, parathyroid hormone increases, resulting in increased bone resorption in order to satisfy the body's demand for calcium [30]. It has been shown that vitamin K improves bone quality and reduces the risk of fracture [31]. In the present study, there were no significant differences in these micronutrients between M-Spar and M-Kata or W-Spar and W-Kata. In comparison with the adequate dietary intake for Japanese [29], the vitamin D and vitamin K intakes of all groups in the present study were well above the recommended targets. Furthermore, body height, LBM, BMI any of the nutrient intakes examined in the present study did not significantly correlate with SOS or %YAM. Thus, the influences of these variables appear to be limited. These results may be due, at least in part, to the fact that the subjects had a narrow range of these variables.

Regarding BMD of karate athletes, Andreoli et al. [13] compared BMD of 21 judo, 14 karate, and 24 water polo athletes who competed at the national and international levels and exercised regularly for at least 3 hours/day, 6 days/week. The results showed that the Judo and karate athletes had significantly higher total BMD than the water polo and 12 age-matched controls. Drozdowska et al. [14] examined skeletal status assessed by QUS at the hand phalanges in 226 karate practitioners (7 to 61 years of age), who had been training karate for at least 6 months. The results showed that, up to age 18, there were no significant differences between the karate practitioners and controls, while afterwards, up to age 35, the difference increased to stabilize after age 35. These authors stated that longer duration, higher frequency, and earlier start of physical training positively influenced the skeletal status and concluded that karate is a sport with a positive

Table 1: Training status of karate practitioners.

	M-SPAR (N=16)	M-KATA (N=10)	W-SPAR (N=12)	W-KATA (N=8)
KARATE TRAINING (YEARS)	16.5 ± 2.7	17.6 ± 2.9	14.7 ± 1.7	16.2 ± 3.6
(DAYS/WEEK)	6.0 ± 1.2	6.4 ± 1.0	6.1 ± 0.5	6.5 ± 0.5
(MIN/DAY)	163.1 ± 28.9	238.0 ± 123.7	163.3 ± 37.7	202.5 ± 52.6
RUNNING (DAYS/WEEK)	3.1 ± 2.6	2.9 ± 2.2	5.1 ± 1.8	3.2 ± 2.0 *
(MIN/DAY)	27.8 ± 18.6	30.0 ± 19.3	40.0 ± 24.6	22.5 ± 10.4
WEIGHT TRAINING (DAYS/WEEK)	3.7 ± 2.6	3.8 ± 2.0	3.2 ± 1.6	4.2 ± 2.2
(MIN/DAY)	46.3 ± 36.3	43.2 ± 24.7	41.7 ± 24.8	60.0 ± 39.3

Mean ± SD *p<0.05 W-spar vs W-Kata

Table 2: Characteristics of the subjects.

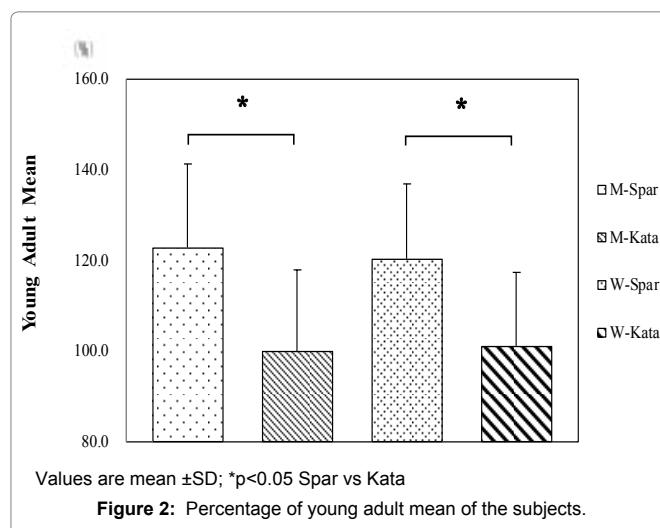
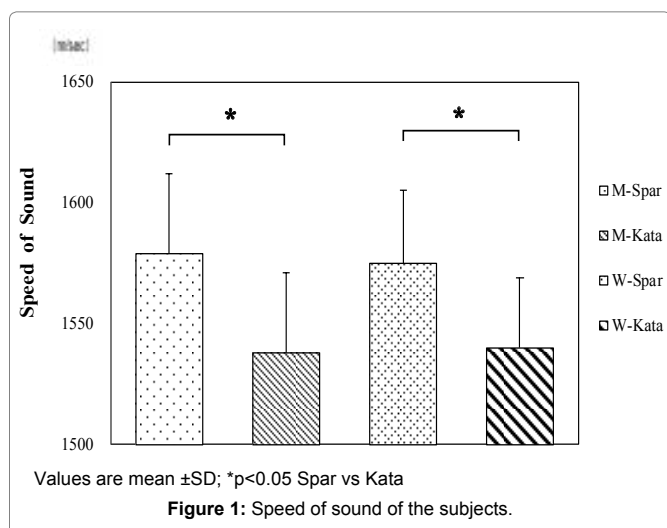
	M-Spar (n=16)	M-Kata (n=10)	W-Spar (n=12)	W-Kata (n=8)
Age (years)	21.7 ± 2.2	22.7 ± 2.5	21.2 ± 1.7	22.8 ± 3.7
Height (cm)	176.7 ± 5.9	168.6 ± 2.5 *	161.2 ± 5.0	156.7 ± 6.6
Weight (kg)	76.4 ± 14.4	70.5 ± 4.8	59.9 ± 6.0	53.9 ± 6.6
BMI (kg/m ²)	24.3 ± 3.3	24.8 ± 2.0	23.0 ± 1.3	21.9 ± 1.7
Fat (%)	12.3 ± 5.5	13.1 ± 4.3	20.5 ± 3.1	21.4 ± 2.3
Fat mass (kg)	10.1 ± 6.6	9.4 ± 3.8	12.3 ± 2.6	11.6 ± 2.3
Lean body mass (kg)	66.4 ± 8.5	61.1 ± 2.8	47.6 ± 4.5	42.3 ± 4.7+

Mean ± SD. BMI: Body mass index. *p<0.05 M-Spar vs M-Kata +p<0.05 W-Spar vs W-Kata

Table 3: Energy and selected micronutrient intakes of the subjects.

	M-Spar (n=16)	M-Kata (n=10)	W-Spar (n=12)	W-Kata (n=8)
Energy (kcal)	2724 ± 760	3231 ± 639	2804 ± 622	2330 ± 509
Calcium (mg)	561 ± 191	683 ± 170	940 ± 405	846 ± 173
Vitamin D (µg)	7.4 ± 2.1	8.6 ± 1.8	9.6 ± 3.0	9.9 ± 2.0
Vitamin k (µg)	167 ± 78	212 ± 86	262 ± 125	320 ± 68

Mean ± SD



influence on the skeletal status with the most significant benefits occurring in adults. These 2 studies [13,14] showed positive effects of karate training on bone status, however, they used male subjects. Incidence of osteoporotic fractures is more frequent in women than in men [15,16]. Furthermore, they examined karate practitioners as a single group. Because high level sparring competitors have been reported to have a higher ability to accelerate the whole body, as assessed by both 10 m sprint test and the standing triple jump test, than their kata counterparts [20,21], the mechanical stress placed on the calcaneus may possibly greater in the sparring practitioners than kata practitioners. The obtained difference, as stated by Koropanovski

et al. [21], could be explained by the specific requirements of the sparring and kata competitions. A success of both the attacking and defensive kumite techniques highly depends on the ability to rapidly initiate the change of body position in horizontal direction, while kata competitors are expected to demonstrate an excellence in kinematic patterns of the prescribed techniques performed at a moderate pace.

As far as we are aware, this is the first study to show bone status of female karate practitioners. Furthermore, we divided karate practitioners into sparring and kata competitors. The results showed that M- and W-Spar had significantly higher mean values of SOS

and %YAM than the respective M- and W-Kata, respectively. Also, M-Spar and W-Spar or M-Kata and W-Kata showed very similar mean values of SOS and %YAM. Thus, practicing karate, especially sparring techniques, may give positive effects on bone status. Also, because %YAM in both M-Kata and W-Kata were very close to 100% YAM, practicing only basic techniques and kata may not affect calcaneal bone status of karate practitioners.

Two limitations of our study need to be mentioned. First, it has been shown that athletes involved in weight-bearing activities [8-12] have greater BMD than non-active control Group in which various sites of BMD were measured with dual energy X-ray absorptiometry (DXA), which remains the optimal method for evaluating BMD. We evaluated SOS of calcaneus using a QUS device, as opposed to the conventional measurement by DXA, because of the following reasons: 1) QUS is a portable and practical machine that measures bone status and involves no x-ray exposure [19]; 2) relatively high correlation coefficient ($r=0.76$) between SOS and BMD at the heel assessed at the location corresponding to that of the QUS measurement has been reported, and SOS value was significantly lower in fracture patients than in participants without fractures [32], and 3) it has further been shown that calcaneal SOS is comparable with DXA in identifying subjects with vertebral fractures [33,34]. Second, a control group was not included in the present study, so that we could not show the mean values of %YAM in the M- and W-Kata were above or below the control values. Thus, further studies with a large number of subjects including a control group are needed to confirm our results.

Conclusion

This study revealed that there were no significant differences in BMI, energy, calcium, and vitamin D and vitamin K intakes between the M-Spar and M-Kata or W-Spar and W-Kata. The M-Spar showed significantly higher SOS and %YAM than the M-Kata. Likewise, the W-Spar showed significantly higher SOS and %YAM than the W-Kata. Thus, practicing karate, especially sparring techniques, give positive effects on bone status.

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