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EFFECTS OF PLAYING BADMINTON ON BONE PROPERTIES USING CALCANEAL QUANTITATIVE ULTRASOUND: A PRELIMINARY STUDY

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Abstract:
Purpose: This study was designed to investigate the effects of playing badminton on calcaneal bone properties. **Methods:** Eleven sedentary collegiate women were recruited. They played badminton for 75 min, 2 days per week, for 10 weeks. The right calcaneus was assessed to measure speed of sound and broadband ultrasound attenuation using a quantitative ultrasound device. A stiffness index was derived from both the speed of sound and broadband ultrasound attenuation. **Results:** After the training period, broadband ultrasound attenuation and stiffness index did not change significantly, whereas speed of sound significantly increased, **Conclusion:** The results indicate that playing badminton influences calcaneal bone properties in a positive manner.

Keywords: speed of sound, broadband ultrasound attenuation, stiffness index, calcaneal bone properties, women, badminton

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1. Introduction

Badminton is a racket sport and is a popular sport in the world. It is estimated 200 million people around the globe play the game (Phomsoupha and Laffaye, 2015; Kwan et al. 2010). In a review study, Allender et al. (2006) stated that participation in sport and physical activity is motivated by enjoyment and the development of social support networks. Thus, playing badminton may be beneficial in increasing physical activity engagement as they have the potential to include elements of enjoyment and social engagement.

Because a high peak bone mass in early adulthood is an important protective factor against osteoporotic fractures in later life (Farr and Khosla, 2015; Winsloe et al. 2009), maximizing peak bone mass before menopause may be important to prevent osteoporosis in premenopausal women. Nordström et al. (1998) reported that adolescent badminton players showed higher bone mineral density (BMD) at weight-bearing sites compared with ice hockey players, despite significantly less average weekly training. Some studies investigated the effects of playing badminton in young males (Nordström et al., 2008; Gustavsson et al., 2003; Tervo et al., 2010), which showed increased BMD. However, to our knowledge, the effects of playing badminton on calcaneal bone properties in women have not been investigated. This study was designed to investigate the effects of playing badminton on calcaneal bone properties in young women.

2. Methods

2.1 Subjects

We recruited 11 collegiate women who had been sedentary for at least one year at one university. All participants were asked to maintain their regular life style including diet and physical activity throughout the experimental period. The study protocol was approved by the Ethics Committee of the University. Informed consent was obtained from each subject.

2.2 Procedure

3-7 days before the 2 orientation sessions and after 10 weeks of training, anthropometric measurements were performed. Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively. Percentage of body fat (%Fat), fat mass and lean body mass were evaluated by the bioelectric impedance analyser (BC-519, Tanita, Tokyo, Japan). The right calcaneus was assessed to measure speed of sound and broadband ultrasound attenuation using a quantitative ultrasound (QUS) device (A-1000 EXP II, Lunar, GE Health Care, Tokyo, Japan). Details of QUS measurements and the coefficients of variation have been presented elsewhere (Yoshimura et al. 2016). In brief, speed of sound (SOS) is the velocity of the ultrasonic wave as it passes through the heel, and broadband ultrasound attenuation (BUA) reflects the frequency dependence of ultrasound attenuation (Glüer, 1997). A stiffness index (SI) was derived from both the SOS and BUA. The reported correlations between the BMD and SOS (r=0.76) and BMD and BUA (r=0.81) at the heel assessed by dual energy X-ray absorptiometry assessed at the location corresponding to that of the QUS measurement (Graafmans et al., 1996).

2.3 Badminton exercises

During the 2 orientation sessions, one of the investigators (YY) instructed the participants on how to properly perform badminton exercises. After the orientation, the subjects played badminton for 75 min per session, 2 days per week, for 10 weeks. Thereafter, advice was given if necessary to perform proper exercises. Each training session started with 5 min stretching followed by 1) 10 min of basic steps such as 2 steps, Chinese steps (extracting essential movements pertinent to badminton), and footwork in 6 directions from starting point, and 2) 15 min of badminton specific shots such as service, drive, drop, smash, hairpin net shot, and clear. After the exercises, each participant played singles for 40 min followed by 5 min stretching.

2.4 Training intensity

Perceived exertion (RPE) using Borg's scale from 6 to 20 (Borg, 1982) and blood lactate was obtained after performing the first and the last (after 10 weeks) 75-min badminton exercise. A 5-μl blood lactate sample was drawn from an earlobe and was analyzed by the Lactate Pro Analyzer (Akray, Tokyo, Japan). The very high correlation coefficients between the Lactate Pro and the ABL 700 Series Acid-Base analyzer, YSI 2300, and Accusport were reported (r=0.98, r=0.99, and r=0.97, respectively) (Pyne et al., 2000).

2.5 Analysis

Data were analyzed with SPSS statistical software 22.0J (Chicago, IL). Results are expressed as mean and standard deviation. The mean differences between before and after the training period were analyzed by paired Mann-Whitney U test, which is non-parametric statistics. Two-sided $p<0.05$ was considered significant.

3. Results

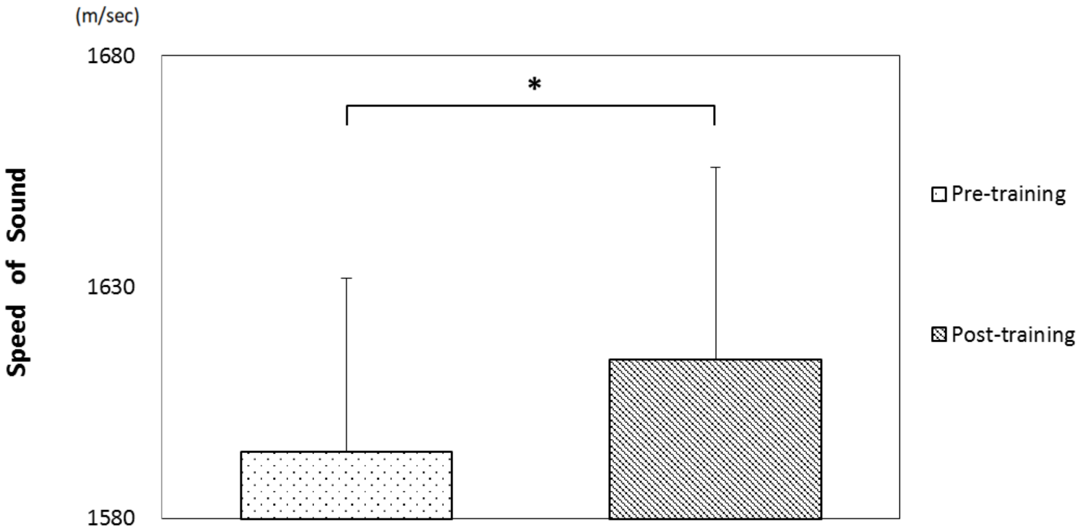
The mean RPE values obtained immediately after the first and last sessions were 11.6±1.0 and 12.3±0.8, respectively. The corresponding mean blood lactate values were 2.6±1.7 mmol•l^{-1} and 3.2±2.2 mmol•l^{-1}, respectively.

After the training period, the mean body weight, % fat, fat mass, and lean body mass did not change significantly (Table 1).

Table 1: Characteristics of the subjects

	pre - training			**post - training**		
Age (years)	20.2	±	1.0			
Height (cm)	156.2	±	5.3	156.4	±	5.3
Weight (kg)	53.2	±	7.0	53.3	±	6.4
Percent body fat (%)	31.5	±	4.7	31.9	±	4.6
Fat mass (kg)	17.0	±	4.6	17.2	±	4.3
Lean body mass (kg)	36.2	±	3.1	36.1	±	2.7

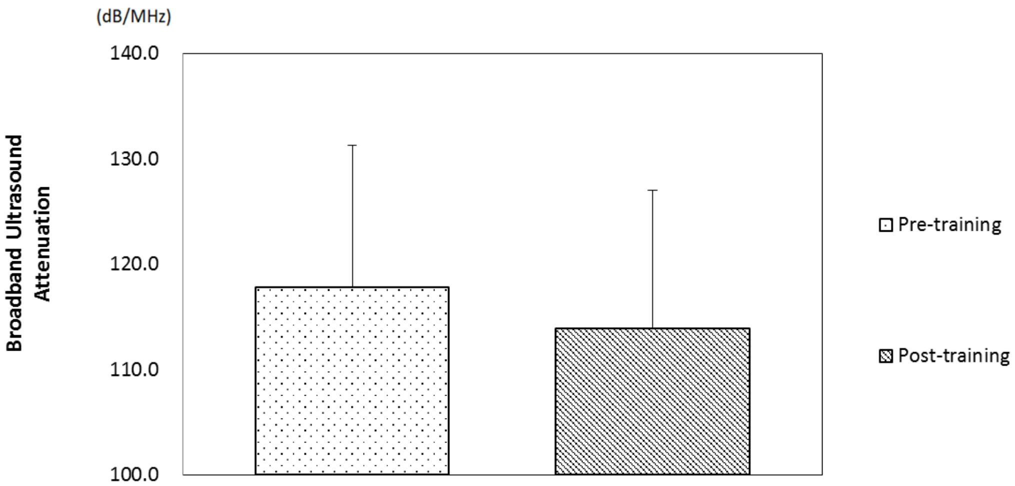
Mean ± SD.



Values are mean ±SD,

*P＜0.05（compared with pre training）

Figure 1: Speed of sound of the subjects



Values are mean ±SD,

Figure 2: Broadband ultrasound attenuation of the subjects

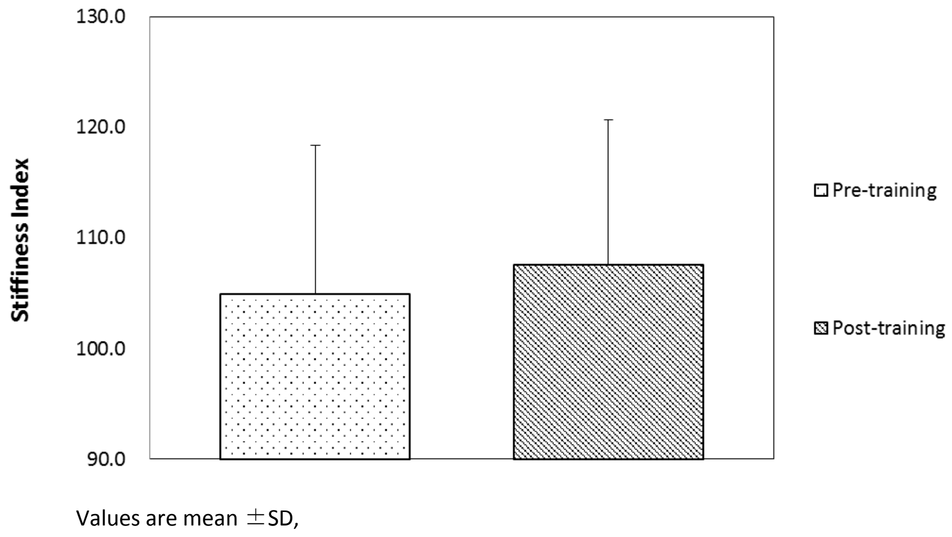


Figure 3: Stiffness index of the subjects

After the training period, the mean SOS significantly increased (Fig 1), whereas the mean BUA and SI showed no significant changes (Fig 2 and 3).

4. Discussion

The aim of the present study was to investigate the effects of playing badminton on calcaneal bone properties in young women. The main results showed that the positive effect of playing badminton on calcaneal bone properties. The positive effect was obtained even though the training intensity in terms of mean blood lactate obtained immediately after the last session appears to be moderate (3.2±2.2 mmol•l^{-1}), and the respective RPE (12.3±0.8) correspond to fairly hard (Borg, 1982). These values are similar to the reported blood lactate and RPE values obtained during karate training (Imamura et al., 1999, 2002; Yoshimura and Imamura, 2010).

Weight-bearing activities have been found to be more effective than nonweight-bearing activities in increasing BMD (Morgan and Jarrett, 2011; Creightonet al., 2001; Andreoli et al., 2001). It appears that the maximum effect is achieved with weight-bearing activities including jumping actions, explosive actions such as turning and sprinting, and fairly few repetitions rather than endurance or nonweight-bearing activities (Nilsson et al., 2013; Nikander et al., 2005; Nikander et al., 2009). The above mentioned badminton exercises used in the present study such as basic steps, Chinese steps, and footwork in 6 directions from starting point, and playing single games include jumping actions and explosive actions.

Regarding playing badminton, Nordström et al. (1998) compared adolescent badminton players, ice hockey players, and controls, whose age, height, and pubertal stage were matched. The results showed that after adjustment for body weight, the badminton players had significantly higher BMD of the trochanter and distal femur compared with the ice hockey players despite a significantly lower weekly average training (5.2±1.9 v.s 8.5±2.2 h/week, respectively). Also, the badminton players had higher BMD compared with the control group at many of weight bearing BMD sites. Longitudinal studies of badminton playing effects in young males (Nordström et al., 2008; Gustavsson et al., 2003; Tervo et al., 2010) showed increased BMD. Nordström et al. (2008) measured BMD and bone mineral content (BMC) at different sites in ice hockey and badminton players and controls, all 17 years of age, and conducted a follow up study 4 years later. At the follow-up, the badminton players had higher BMD and BMC at all sites compared with controls. After adjustment for body weight, the badminton players had higher hip BMD and BMC, femoral neck BMC, and humeral BMC compared with ice hockey players. From these results, the authors concluded that badminton is associated with higher gains in bone mass and size compared with ice hockey after puberty in men. Other 3-year (Gustavsson et al., 2003) and 12-year (Tervo et al., 2010) longitudinal studies showed similar results. The results of these studies (Nordström et al., 1998; Nordström et al., 2008; Gustavsson et al., 2003; Tervo et al., 2010) suggest that higher BMD and/or BMC found in the badminton players possibly be associated with higher strains on the bones from badminton play than ice hockey play. In the present study, the positive effect of playing badminton on calcaneal bone properties was also observed in sedentary collegiate women.

5. Limitations

The result of the present study needs to be interpreted with caution because the number of subjects is small, and there were no controls. Even with these limitations taken into consideration, it seemed worthwhile to conduct this preliminary study because, as far as we are aware, this is the first study to show the positive effects of playing badminton on calcaneal bone properties in sedentary young women.

6. Conclusion

This study shows that playing badminton can improve calcaneal bone properties in sedentary young women.

Competing Interest
The authors declare that they have no competing interests.

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