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Calcaneus quantitative ultrasound and Body Composition in Preschool Children: Physical Activity Consideration

Ultrasonido Cuantitativo de Calcáneo y Composición Corporal en Niños Preescolares: Consideración de Actividad Física

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SUMMARY: The aim of this research was to determine the difference in Calcaneus quantitative ultrasound (QUS) and body composition according to physical activity in preschool children. We recruited 296 healthy children (112 girls and 184 boys) from different kindergartens in Vojvodina, Serbia. Children were evaluated for body composition. Quantitative ultrasound (QUS) measurements of the heel were performed using the Speed of sound, Broadband Ultrasound Attenuation, Quantitative Ultrasound Index and Estimated bone mineral density for further analysis. Furthermore, children were divided into three groups according to physical activity. Apart from the differences in Body fat % and body mass, there were no significant group differences for BMI, waist circumference and abdominal skinfold ($p>0.05$). The ANOVA showed significant differences ($p<0.05$) in all QUS measurements between three different intensities of physical activity. The results show that Body Mass and Body fat % were important predictors that discriminate children according to physical activity. Moreover, the results show that beside BMI and Body fat %, all calcaneus QUS measurements showed differences according to physical activity level.

KEY WORDS: Bone health; Body weight; Children; Difference.

INTRODUCTION

Physical activity (PA) is very important for children for healthy living, and inactivity has been identified as a significant predictor for overweight and obesity during childhood (Cantell *et al*., 2012). Research on PA in preschool-aged is children difficult due to the fact that there are no evidence-based guidelines (Katzmarzyk & Ardern, 2004). There are also contradictory statements concerning the amount of PA in preschool children. The National Association for Sport and Physical Education (NASPE) has released PA guidelines for young children that recommend at least 120 min of PA per day, with half the time spent in structured settings and the other half in unstructured settings (Cantell *et al*.). However, aforementioned authors found other recommendations with at least 60 min of moderate-to-vigorous intensity PA daily.

Moderate to high intensive physical activity, including jumping and resistance training, can help with the bones health maintenance in mature years (Kohrt *et al*., 2004). Significant positive links have been reported between regular participation in sports and mineral density of bones in childhood (Slemenda *et al*., 1991; Schönaü *et al*., 1993; Ruiz *et al*., 1995). Recently, Harvey *et al*. (2012) have shown that the levels of the typical daily physical activity are positively correlated with bone density in four-year-old children. Beside the fact that physically active children have greater bone mass or density than sedentary children (Heinonen *et al*., 1993; Heinonen *et al*., 1995; Lima *et al*., 2001), the researchers have tried to connect aerobic activities with bone mass, but the results are inconsistent. Laabes *et al*. (2008) recruited male athletes from different sports and found that football is a significant determinant of speed of sound independent of age, height, weight and BMI. Troiano *et al*. (1995), reported that the prevalence of overweight is increasing among boys and girls of all age groups and suggested increasing physical activity as a means to address this important health problem.

Physical activity during pubertal growth stimulates both bone and skeletal muscle hypertrophy to a greater

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degree than observed with normal growth in non-physically active children (Vicente-Rodríguez, 2006). However, there is an increased sedentarism in children, especially in girls (Goran *et al*., 1999), which is an important issue concerning the association of PA and bone density. Therefore, it is of great importance to know how PA affects bone development and accordingly what type of activity is best suitable for children. Thus, the aim of this research was to determine the difference in Calcaneus QUS and body composition according to physical activity in preschool children.

MATERIAL AND METHOD

Subjects. We recruited 296 healthy children (112 girls and 184 boys) from different kindergartens in Vojvodina, Serbia. Descriptive characteristics of participants are presented in Table 1. Parents were informed about the assessment from the school physician. All individuals and their parents gave their consent to participate in the study before investigation. The inclusion criteria for participation in the study were as follows: not suffering from chronic diseases or taking medication on a regular basis, not having a history of diseases that could affect bone, and not having immobilized any part of the body during 6 months before the evaluation. Eight children did not agree to take part in the study. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the ethical committee of each survey centre.

Testing procedures. Medical history from all children was obtained from their school physician. Height was measured on a portable stadiometer, to the nearest 0.5 cm. Body composition was determined by a body-fat analyzer (BF 905, Maltron, UK). Body mass index (BMI) was calculated through the following formula: body weight (kg) ÷ height2 (m). Weight circumferences was measured to the nearest 0.1 cm at the level of the iliac crest while the subject was at minimal respiration. Abdominal skinfold thickness was measured with a skinfold caliper.

For PA habits, each parent was asked how often their child participated in general PA (e.g., going for walks, playing outdoors, skating), and how often they participate in organized PA (e.g., swim class, gym class). Participating children were asked how many times per week they "played or exercised enough to make them sweat or breathe hard." These activities did not exclude school-related involvements such as physical education. We consider low PA when children could not accumulate at least 60 min of moderate-to-vigorous PA daily. Moderate PA involves 60 min of moderate-to-vigorous PA daily, while high PA includes recommendation in which children must be engage in at least 120 min of PA per day, with half the time spent in structured settings and the other half in unstructured settings.

Bone density. Quantitative ultrasound (QUS) measurements of the heel were performed using “Sahara” sonometer (“Hologic,” Bedford, MA). We used the calcaneus bone for QUS assessment because it contains a large percentage of trabecular bone, which has a high metabolic turnover rate (Töyräs *et al*., 2002). The primary parameters measured with ultrasound were BUA and speed of sound (SOS). BUA (dB/MHz) is the attenuation of sound waves as they pass from the transmitting transducer to the receiving transducer. SOS (m/sec) is the speed the ultrasound signal travels from one transducer to the other. Normal bone has a higher attenuation (BUA) and speed of sound (SOS) than osteoporotic bone. These two parameters can be combined to form a new parameter, the quantitative ultrasound index (QUI) referred as ultrasound stiffness. QUI was calculated automatically using the equation “QUI = 0.41 ¥ (BUA + SOS) - 571,” without a unit of measurement (Frost *et al*., 2000; Kwok *et al*., 2012). The Est. BMD (g/cm2) was calculated using the following equation “EBMD = 0.002592 ¥ (BUA+ SOS)- 3.687” (Frost *et al*.). All measurements were performed by the same investigator throughout the study. The EBMD was not a direct measurement of the heel BMD. However, EBMD has proven to be a useful parameter for the assessment of calcaneal BMD in previous studies (Frost *et al*.). To examine short-term precision in vivo, 10 children had two repositioned measurements. The coefficient of variation percent (CV%) was 3.1, 1.6, 3.6 and 4.4 % for BUA, SOS, QUI and estimated BMD, respectively.

Statistical analysis. Data analysis was performed using the Statistical Package for the Social Sciences (v13.0, SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$. The mean and standard deviations were calculated for the subject characteristics, body composition and QUS measurements. The subject characteristics of the groups were compared with one-way analysis of variance (ANOVA). When the ANOVA indicated a significant difference ($p < 0.05$), Tukey’s range method was used as the post-hoc test.

RESULTS

Descriptive statistics for the different physical activities of participants are shown in Table I. Apart from the expected differences in Body fat% and body mass, there were no significant group differences for BMI, waist circumference and abdominal skinfold ($p>0.05$). Moreover, children with low PA were significantly taller than vigorous, as well as moderate PA children.

Table I. Body composition in three different levels of PA.

	Moderate PA (n=137)	High PA (n =112)	Low PA (n =47)	p
Height	120.34±8.54*	115.26±7.76**	125.92±9.34*	0.001†
Weight	23.85±5.16*	21.50±4.49**	26.78±6.22*	0.001†
BMI	16.30±1.88	16.02±1.75	16.71±2.37	0.108
BFAT	18.92±3.73	19.02±3.07**	20.03±3.38*	0.033†
Waist circumference	56.84±5.75	56.57±6.42	57.34±7.31	0.70
Abdominal skinfold	6.93±3.88	6.82±3.37	7.44±3.97	0.40

†Significant difference between groups (p<0.05); *Significantly different from low PA; **Significantly different from low PA;

Table II. QUS measurement in three different levels of PA.

	Moderate PA (n =116)	High PA (n =103)	Low PA (n =47)	p
EBMD	0.52±.073	0.54±.094*	0.49±.071	.007†
QUI	94.56± 12.08	97.63±14.89*	89.92±11.75	.004†
BUA	57.73± 15.33	59.37±18.41*	52.24±12.74	.044†
SOS	1566.15±17.72	1571.27±23.35*	1560.58±21.71	.012†

†Significant difference between groups (p<0.05); *Significantly different from low PA; SOS- Speed of sound; BUA- Broadband Ultrasound Attenuation; QUI- Quantitative Ultrasound Index; EBMD- estimated bone mineral density.

Group comparisons with respect to the Calcaneus QUS measurement and according to physical activity are shown in Table II. The ANOVA showed significant differences (p<0.05) between three different intensities of PA. Post hoc test revealed significant differences between vigorous and low PA in all measured variables.

DISCUSSION

Bone health in children recently became very important medical care that leads to an increased interest in bones densitometry. Accordingly, the present study involved a population of healthy preschool children and provides novel data about bone density as indicated by QUS measurements. The results show that Body Mass and Body fat% were important predictors that discriminate children according to physical activity. Moreover, the results show that beside BMI and Body fat%, all calcaneus QUS measurements showed differences according to physical activity level.

Regarding body composition, in the present study we found that calcaneus QUS variables were significantly different according to physical activity. Children with low PA are significantly heavier than other groups, with higher body fat %. Interestingly, there were no differences in BMI between groups. Data from the previous studies suggest that high levels of PA in children and young adults could be an effective preventive strategy to reduce the risk of osteoporosis in later life.

Cvijetic *et al*. (2003) and Rauch *et al*. (2004) and more recently Gracia-Marco *et al*. (2012) using the linear regression found that only Lean Mass contributed significantly to the variance in BUA values. The aforementioned authors explain these results with mechanostat theory, which predicts that the increase in muscle mass during development creates the stimulus for the increase in bone mass.

Calcaneus QUS measurement is important research tool for detecting low bone mass in pediatric population (Specker & Schoenau, 2005). The results from our study concerning a bone benefit with physical activity is consistent with cross-sectional studies showing that physically active children have greater bone mass or density than sedentary children (Slemenda *et al.*; Boot *et al.*, 1997; Jones & Dwyer, 1998). Janz *et al.* (2008), studying a sample which included 449 children, with an average age of 11, and using a questionnaire for the self-evaluation of the physical activities of children, noted a correlation between body height, body weight and maturity and bone mineral content. Additionally, longitudinal studies show that high childhood activity is associated with high adult bone density (Välimäki *et al.*, 1994; Welten *et al.*, 1994).

Our study showed differences in all calcaneus QUS measurements according to physical activity level. There is a need for further longitudinal research to find the best time during the growth period when loading is most effective. Physical activity and calcium intake are considered the major environmental factors influencing bone mass. However, limitation of our study could be the fact that measured physical activities, such as the intensity and duration of recreation and sport activities, were not analyzed objectively. Additionally, dietary calcium intakes were not considered for analysis in this research.

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RESUMEN: El objetivo de esta investigación fue determinar la diferencia entre el ultrasonido cuantitativo (USC) de calcáneo y la composición corporal según la actividad física en niños en edad preescolar. Se estudiaron 296 niños sanos (112 niñas y 184 niños) de diferentes jardines infantiles en Vojvodina, Serbia. Se evaluó la composición corporal de los niños. Las medidas de USC del talón se realizaron utilizando la velocidad del sonido, atenuación de ultrasonido de banda ancha, el índice de ultrasonidos cuantitativos y la densidad mineral ósea estimada para un análisis posterior. Los niños se dividieron en tres grupos según actividad física. Además de las diferencias de porcentaje de grasa corporal y masa corporal, no se observaron diferencias significativas de grupo en el índice de masa corporal (IMC), circunferencia de cintura y el pliegue abdominal (p> 0,05). El test de ANOVA mostró diferencias significativas (p <0,05) en todas las mediciones USC entre tres diferentes intensidades de actividad física. Los resultados muestran que la masa corporal y la grasa corporal fueron indicadores importantes que permiten diferenciar a los niños según la actividad física. Por otra parte, los resultados muestran que además del IMC y el porcentaje de grasa corporal, todas las mediciones de USC del calcáneo mostraron diferencias según el nivel de actividad física.

PALABRAS CLAVE: Salud osea; Peso corporal; Niños; Diferencia.

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