Gender differences among prepubertal children on bone mineral content, bone mineral density, and physical activity

Stampoulis Th.[1], Leontsini D.[1], Avloniti, A.[1], Chatzinikolaou A.[1], Fatouros I.[2], Kambas A.[1]

[1]School of Physical Education and Sport Science, Democritus University of Thrace
[2]Department of Physical Education and Sport Science, University of Thessaly
akampas@phyed.duth.gr

Abstract

Purpose of this study was to investigate the gender effect on physical activity (PA) and bone mineral content (BMC) and bone mineral density (BMD) of total body less head (TBLH) and lumbar spine (L1-L4) in tanner stage I greek schoolchildren. PA was measured by ActiGraph GT3X+ accelerometer and Dual-energy X-ray Absoroptiometry (DXA) used to assess BMC and BMD of participants (52 boys, 58 girls, Tanner stage I, aged 7-9 years). Students t-test for independent samples was used to evaluate gender differences. Results showed that there was not any gender difference in BMC and BMD of TBLH and L1-L4, but boys counted significantly more steps/day than girls (11.636±2471.56 vs 9953.71±1638.8, respectively, $p<0.001$). Only 1/3 of boys and girls met MVPA's recommendation. In conclusion, boys were more active than girls, but there was no difference in bone status of TBLH and L1-L4 in Tanner stage I of Greek schoolchildren.

***Key words**: prepuberty, bone status, physical activity*

Introduction

Peak bone mass is achieved during the second and third decade of life and it is of great importance to prevent osteopenia and osteoporosis in later life (Berger et al., 2010; Holroyd, Cooper, & Dennison, 2008). Prepuberty is proposed to be an opportunity period of life to enhance peak bone mass due to the absence of sex steroids activity and main hormonal effect by growth hormone and insulin-like growth factor I (Bonjour & Chevalley, 2014; Breen et al., 2011; MacKelvie, Khan, & McKay, 2002). Bone status during these years is supposed to have no differences between males and females (Medina-Gomez et al., 2016; Nguyen et al., 2001). However, there are mentioned sex differences in bone mineral density (BMD) of hip and spine in children aged 5 years old (Willing et al., 2005) and in total body bone mineral content (BMC) in children aged 8.5 aged years old (Horlick et al., 2000).

These differences have been related to the body composition of children, because boys reported higher lean mass than girls which affects BMC and BMD at multiple skeletal sites (Arabi et al., 2004; Baptista et al., 2012; Medina-Gomez et al., 2016). In a recent study, Cheng et al. (2020) found that fat-free mass is a major determinant of bone stiffness in children 6 years old and the relationship continued till 6 years. The main difference of this study was the use of the calcaneal quantitative ultrasound method instead of dual-energy X-ray absorptiometry (DXA) which most studies accept as a reference method for bone status assessment (Bachrach et al., 2016).

Physical activity is one of the major environmental factors that influence bone mass directly through the applied mechanical loads on the skeleton (Hind & Burrows, 2007; Ren et al., 2015; Rosa, Simoes, Magalhaes, & Marques, 2015). Indirectly, physical activity influences body composition, enhancing lean mass and decreasing fat mass (Baxter-Jones, Eisenmann, Mirwald, Faulkner, & Bailey, 2008; Butte et al., 2016; Fritz, Rosengren, Dencker, Karlsson, & Karlsson, 2016). Children are recommended to spend at least 60 minutes in moderate-to-vigorous physical activity (MVPA) which is associated with 13000 to 15000 steps/day for males and 11000 to 12000 steps/day for female primary schoolchildren (Tudor-Locke et al., 2011). Sex differences in physical activity levels in school-aged children are very often (Loucaides, Jago, & Theophanous, 2011; Michalopoulou et al., 2011; Riddoch et al., 2004; Telford, Telford, Olive, Cochrane, & Davey, 2016) but there is little evidence if these differences exist in Tanner stage I Greek schoolchildren.
This study aimed to examine the effect of gender on the whole-body bone status and physical activity levels in a sample of Tanner stage I Greek schoolchildren.

Methods

Study population

Healthy children aged 7-9 years old (52 boys, 58 girls) were recruited for this study through briefing sessions in local primary schools of Komotini, Thrace. The volunteers were informed of the experimental design and its possible dangers due to DXA scans. Both children and parents signed the informed consent and they filled up a medical history questionnaire. Inclusion criteria: 1) the absence of pubertal signs (Tanner stage I)(Tanner & Whitehouse, 1976), 2) no use of medication systematically, 3) no chronic or bone disease and 4) no orthopedic disabilities. The study's protocol was approved by the ethical committee of the University of Thessaly.

Research Design

The study took place in the laboratory of the Department of Physical Education and Sports Sciences in Komotini. Each child visited twice the laboratory to assess physical activity and bone status through the DXA method. At the first visit, a well-trained member of the laboratory team examined the participants' anthropometric characteristics and an experienced pediatrician assessed the pubertal stage. Every volunteer took detailed instructions about the accelerometer and the suggested way to wear it. At the second visit, participants had to bring back accelerometers and assessed their total body and lumbar spine BMC and BMD by a senior radiologist through a DXA device.

Measurements

Anthropometrics

All anthropometric measurements were made after a 3-4-hour fast while subjects were wearing light clothing and without shoes. Body weight was assessed by using a mechanical column scale (Beam Balance 710, Seca, UK) calibrated to the nearest 0.1kg and standing height was measured with a roll-up measuring tape with wall attachment to the nearest 0.1cm (Seca 206, UK). Body Mass Index was calculated by the equation: BMI= Weight (kg)/ Height (m^2). Body fat was assessed through a whole-body scan in a DXA device (DXA, GE Healthcare, Lunar DPX NT, Diegem, Belgium).

Physical activity

To assess children's physical activity, the ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, FL, USA) was used. The device is placed into an elastic belt and positioned in line with the anterior axillary on the right hip. The participants were told to wear it 24 hours/day for 7 consecutive days, excluding periods of water exposure (Sasaki, John & Freedson, 2011).

Bone status assessment

BMD and BMC were determined at the lumbar spine (L1-L4) and total body less head (TBLH) by DXA using LUNAR DPX NT (GE Healthcare, Diegem, Belgium). For TB scan each child lay supine upon the scanning table with the senior radiologist stabilizing the child's legs and arms. For the L1-L4 scan, an appropriate square cushion is placed under the child's lower legs with thighs as close to 90 degrees angle to the body as possible with the spine touching the scanning table. One repeat measurement was attempted in the case of the child's movement. All scans were analyzed by the senior radiologist using the enCORE software by the same manufacturer.

Statistical analysis

All parameters were found to have normal distribution after the Kolmogorov-Smirnov test was used. Mean values were compared using the Student t-test for Independent Samples, with a p-value <0.05 considered statistically significant.

Results

There was no statistical significance between boys and girls in age, weight, height, BMI, and body fat as presented in Table 1.

Table 1: Descriptive characteristics of the participants (Mean±SD)

	Total (n=110)	Boys (n=52)	Girls (n=58)
Age (years)	7.93±0.44	8.00±0.45	7.87±0.42
Weight (kg)	30.11±6.74	30.35±6.77	29.90±6.77
Height (cm)	130.89±8.13	131.29±7.93	130.54±8.35
BMI (kg/m^2)	17.44±2.69	17.48±2.74	17.40±2.66
BF (%)	27.56±9.60	24.41±9.93	30.38±8.42*

BMI=Body Mass Index (kg/m^2), BF= Body Fat, *Statistically significant difference between boys and girls, p<0.01

There was not any significant difference between boys and girls in TBLH BMC (740.09±197.27g vs 718.34± 211.04g, respectively p>0.05) and BMD (0.75±0.06g/m^2 vs 0.75±0.07g/m^2, respectively p>0.05). Also, boys had no significant difference with girls in L1-L4 BMC (22.08± 4.03g vs 22.27±5.44g, p>0.05). Girls were found to have greater BMD than boys, but this was not statistically significant (0.71±0.09g/m^2 vs 0.68±0.08g/m^2, p= 0.094) (Figure 1).

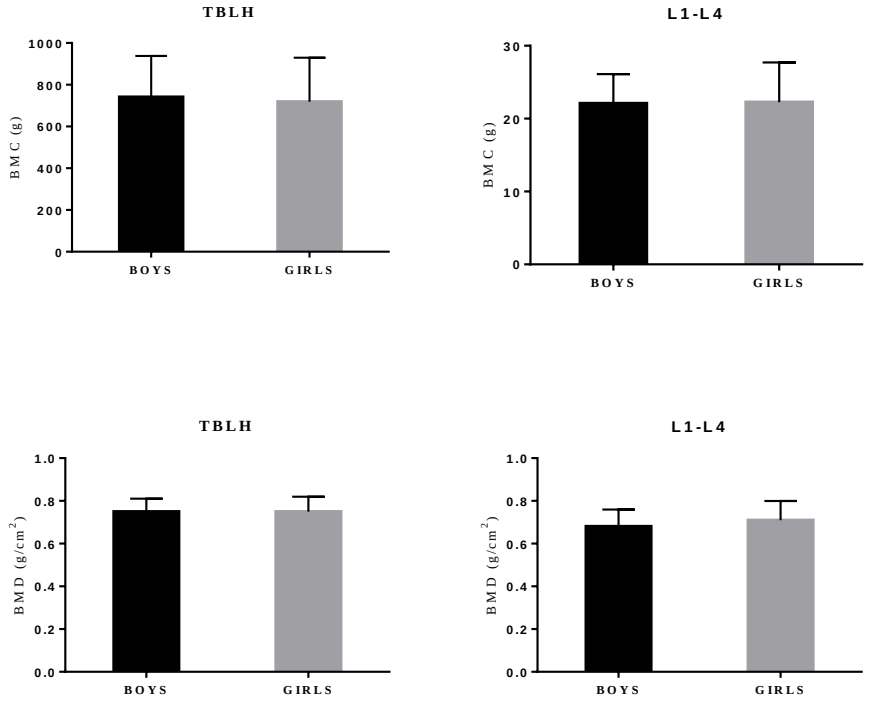

Figure 1. Differences between boys and girls in BMC and BMD of TBLH and L1-L4. TBLH: Total Body Less Head, L1-L4: Lumbar spine 1-4, BMC: Bone Mineral Content, BMD: Bone Mineral Density

Boys were statistically significant more active than girls, but less than half of them met the recommendation for participation in MVPA more than 60min/day or PA greater than 13.000 steps/day for boys and 11.000steps/day for girls (Tudor-Locke 2011), as it is shown in Table 2.

Table 2. Physical activity status in participants (mean±sd)

	Boys (n=52)	Girls (n=58)
PA (steps/day)	11.636±2471.56	9953.71±1638.8*
MVPA (%)	28.8	32.8

PA: Physical Activity, MVPA: Moderate-to-Vigorous Physical Activity * Statistically significant difference between boys and girls, $p<0.001$.

Discussion

The present study shows that Tanner stage I boys and girls had no difference in their bone status of TBLH and L1-L4, but boys were more active and had lower body fat than girls. The absence of any sex difference in BMC or BMD of this study is in agreement with the study of Nguyen et al. (2001) who found that prepubertal males and females aged 6-10 years old presented similar BMC and BMD in total body and spine. They also found a greater spine BMD for girls than boys without any statistical significance, as in the present study. On the other hand, a study with children aged over 10 years found that at Tanner stage I boys had greater L1-L4 BMD than girls, but this was overturned in Tanner stage 2 (Arabi et al., 2004).

Boys were found to be more active than girls due to the higher amount of steps per day, but both sexes presented only 1/3 to meet MVPA's recommendations. In a similar greek population has been also found that boys were more active and met MVPA's recommendation, but girls did not (Afthentopoulou, Venetsanou, Zounhia, & Petrogiannis, 2018; Michalopoulou et al., 2011). Possible explanations of this difference could be weaker participation in PA at school or in sports by girls(Telford et al., 2016) or existing cultural stereotypes that encourage girls' participation in low-intensity activity levels or no activity (Blatchford, Baines, & Pellegrini, 2003; Hardin & Greer, 2009; Venetsanou & Kambas, 2016).

In conclusion, the present study demonstrates that there were no significant differences between BMC and BMD of TBLH and L1-L4 in Tanner stage I greek schoolchildren, both gender had similar participation in MVPA, although boys counted more steps/day than girls.

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