



## Impact of Futsal and Swimming Participation on Bone Health in Young Athletes

by

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*Physical activity plays a crucial role in bone mass acquisition during childhood and adolescence, with weight-bearing and high-impact sport activities being more beneficial. This study sought to evaluate the impact of different sports activities on bone mineral density and content in male Portuguese athletes. Seventy adolescent boys (aged 12-15 years) including 28 futsal players (FG), 20 swimmers (SG) and 22 non-athletic adolescents used as control subjects (CG), participated in the current study. Areal bone mineral density (aBMD) and areal bone mineral content (aBMC) were measured by dual energy x-ray absorptiometry (DEXA). Futsal players had significantly higher aBMD (lumbar spine - FG:  $0.95 \pm 0.18$ , SG:  $0.80 \pm 0.13$ , CG:  $0.79 \pm 0.13$  g/cm<sup>2</sup>,  $p = 0.001$ ; pelvis - FG:  $1.17 \pm 0.21$ , SG:  $0.91 \pm 0.12$ , CG:  $0.98 \pm 0.10$  g/cm<sup>2</sup>,  $p < 0.001$ ; lower limbs - FG:  $1.21 \pm 0.19$ , SG:  $0.97 \pm 0.10$ , CG:  $0.99 \pm 0.09$  g/cm<sup>2</sup>,  $p < 0.001$ ) and aBMC (lumbar spine - FG:  $51.07 \pm 16.53$ , SG:  $40.19 \pm 12.47$ , CG:  $40.50 \pm 10.53$  g,  $p = 0.013$ ; pelvis - FG:  $299.5 \pm 110.61$ , SG:  $170.02 \pm 55.82$ , CG:  $183.11 \pm 46.78$  g,  $p < 0.001$ ; lower limbs - FG:  $427.21 \pm 117.11$ , SG:  $300.13 \pm 76.42$ , CG:  $312.26 \pm 61.86$  g/cm<sup>2</sup>,  $p < 0.001$ ) than swimmers and control subjects. Data suggest that futsal, as a weight-bearing and high or odd-impact sport, may improve bone mass during childhood and adolescence.*

**Key words:** bone mineral density, futsal, swimming, youth.

### Introduction

Osteoporosis is a disease characterized by reduced bone mass and deterioration of bone micro-architecture resulting in a higher risk of bone fracture (Kanis et al., 1994). Currently, it is a serious public health issue particularly due to the increasing prevalence over the past decades, as well as to the associated morbidity, with considerable medical, social and financial implications in society (Cauley, 2013; Rossini et al., 2016; World Health Organization, 2007). Although manifesting mainly in adults, it seems to have origin in childhood and adolescence, with existing evidence that the risk of osteoporosis and

its related-comorbidities may be reduced by maximizing the accrual of peak bone mass in the first decades of life (Khan et al., 2000; Lappe et al., 2015).

Physical activity is accepted as an effective strategy to improve bone mass during childhood and adolescence (Janssen and Leblanc, 2010; Strong et al., 2005), particularly by allowing a higher peak bone mass during the age range in which growth and skeletal maturity occur (Malina et al., 2004). However, different physical activities do not equally influence bone mass acquisition (Hind and Burrows, 2007; Tenforde and

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Fredericson, 2011) as a variety of cross-sectional and observational studies have suggested that enhanced bone mass is most strongly associated with weight-bearing activities, particularly those that involve high-impact or odd-impact loading (Hind and Burrows, 2007; Nordstrom et al., 1998; Scofield and Hecht, 2012). In this sense, the specific physical activity impact on the skeletal and muscular system seems to be one of the determinants of distinct bone mass acquisition.

Futsal is a growing in popularity team sport that is widely played worldwide by men and women, boys and girls, in both professional and amateur leagues (Barbero-Alvarez et al., 2008). It consists in an intermittent high-intensity sport, involving various types of runs, with fast changes of directions, starts, stops, jumps and kicks, resulting in large ground reaction forces at the skeleton and a consequent increase in bone formation (Anliker et al., 2013; Barbero-Alvarez and Soto, 2008; Castagna et al., 2009; Hart et al., 2016). Futsal can be classified as a weight-bearing sport, although no studies have investigated the effects of its practice on bone mass. Understanding of these effects might assist public health authorities to identify a new strategy useful for promoting bone health during childhood and adolescence.

The objective of this cross-sectional study was to investigate the bone mass of adolescent male futsal players, comparing it with swimmers (a non-weight-bearing and low-impact sport) and a control group (subjects of the same gender and age). It was hypothesized that the systematic practice of a weight-bearing and high-impact sport (futsal) would have a significant effect on bone mass in adolescent boys.

## Methods

### *Participants*

Seventy adolescent boys were divided into three groups according to their sport participation (all participating in 45-90 min physical education classes): futsal players (FG; N = 28, 13.5 ± 1.2 years, ≥ six years of previous futsal training and three training sessions per week (≈ 4 h per week), swimmers (SG; N = 20, 13.2 ± 1.2 years, ≥ six years of previous swimming training and six training sessions per week (≈ 9 h per week) and a control group (CG; N = 22, 13.4 ± 0.9 years, not participating in any kind of regular or

organized sport activity for ≥ 3 years). Prior to the tests, the following variables were registered: age, body height, body mass and training background for each participant. The experimental protocol followed the Declaration of Helsinki of the World Medical Association guidelines for research with humans, and was approved by the research committee of the Faculty of Sport of the University of Porto. All participants were fully informed about the aims, experimental protocol and procedures of the study, and their parents provided written informed consent.

### *Measures*

#### *Anthropometry*

Body height and mass were measured with a fixed stadiometer (± 0.1 cm; Holtain Ltd.) and a body fat monitor (± 0.1 kg; Tanita®, BC-418MA). The body mass index (BMI) was calculated using the standard formula: body mass (kg)/height<sup>2</sup> (m).

#### *Body composition*

Areal bone mineral density (aBMD, g/cm<sup>2</sup>) and areal bone mineral content (aBMC, g) were evaluated using dual-energy X-ray absorptiometry (DXA; Hologic QDR 4500A, Hologic Inc., Waltham, MA, USA), with the equipment calibrated according to the manufacturer's instruction. Subjects were scanned in the supine position, with aBMD and aBMC being measured for the lumbar spine (L1-L4), pelvis and lower limbs using standard protocols. A well-trained technician performed all exams and analysed all total body scans. Laboratory precision errors for regional analysis of the complete body scan, defined by the coefficient of variation (CV) for repeated measures estimated in young volunteers with repositioning, were as follows: aBMC < 3.5% and aBMD < 4%.

#### *Maturational status*

The maturational status assessment was based on the evaluation of secondary sexual characteristics, particularly the stage of pubic hair, using established literature criteria (Tanner, 1962).

#### *Daily physical activity*

Daily physical activity was assessed using GT1M accelerometers (Actigraph, 72 Pensacola, Florida), with all participants provided ≥ 5 days of data with ≥ 500 min of information per day. For assessing the volume and intensity of the participants' physical activity, mean minutes of moderate to vigorous intensity physical activity

per day (MVPA) were analysed.

#### Calcium intake

Adolescents completed questionnaires regarding medical and training history under guidance of the same investigator. Daily intake of dairy products was obtained from every subject by a 24 h nutritional recall interview to calculate the calcium intake. The conversion of food into nutrients was performed by the Food Processor SQL® (ESHA Research, USA).

#### Statistical analysis

Descriptive statistics (means and standard deviations) were calculated for the anthropometric, nutritional and maturity status, sports experience and bone related variables.

None of the characteristics showed significant deviations from a normal distribution (Shapiro-Wilk test). Differences between groups were tested using unpaired sample t-tests (years of experience, sessions and hours of training per week), one-way ANOVA and chi-square tests (maturity status). The Bonferroni test for multiple comparisons was used to check for specific differences between groups. Effect size was calculated using eta-squared ( $\eta^2$ ) and interpreted as small (0.01), medium (0.06) or large (0.14)

(Cohen, 1988). The level of significance was set at 0.05. Statistical procedures were carried out using SPSS 24.0.

**Table 1.**  
*Anthropometric, nutritional, physical activity and maturity status  
and sport experience variables and regional areal bone mineral density (aBMD)  
and areal bone mineral content (aBMC) of study participants.*

Variables	FG	SG	CG	<i>p</i>
Age (years)	13.5 (1.2)	13.2 (1.2)	13.4 (0.9)	0.541
Body height (cm)	165.2 (9.6)	162.1 (10.6)	161.4 (8.2)	0.152
Body mass (kg)	53.7 (12.8)	57.1 (10.3)	52.9 (8.2)	0.131
BMI (kg/m <sup>2</sup> )	20.6 (3.1)	20.3 (2.3)	20.2 (2.8)	0.563
Years of experience	6 (1)	6 (2)	--	0.131
Sessions training per week	3 (1)	6 (1)	--	<0.001
Hours of training per week	4 (1)	9 (2)	--	<0.001
Maturity status n (%)				0.182
PH 2-3	15 (53.6)	13 (65.0)	17 (77.2)	
PH 4-5	13 (46.4)	7 (35.0)	5 (22.8)	
Calcium intake (mg)	1106 (103)	1054 (118)	1050 (130)	0.163
MVPA (min·d <sup>-1</sup> )	54.3 (13.8)	55.7 (16.4)	51.2 (10.8)	0.552
<b>aBMD (g/cm<sup>2</sup>)</b>				
Lumbar spine	<b>0.95 (0.18)*</b>	0.80 (0.13)	0.79 (0.13)	0.001
Pelvis	<b>1.17 (0.21)*</b>	0.91 (0.12)	0.98 (0.10)	<0.001
Lower limbs	<b>1.21 (0.19)*</b>	0.97 (0.10)	0.99 (0.09)	<0.001
<b>aBMC (g)</b>				
Lumbar spine	<b>51.07 (16.53)*</b>	40.19 (12.47)	40.50 (10.53)	0.013
Pelvis	<b>299.5 (110.61)*</b>	170.02 (55.82)	183.11 (46.78)	<0.001
Lower limbs	<b>427.21 (117.11)*</b>	300.13 (76.42)	312.26 (61.86)	<0.001

*Data are presented as means (standard deviation). PH: stage of pubic hair;*

*aBMD: areal bone mineral density; aBMC: areal bone mineral content;*

*MVPA: moderate to vigorous intensity physical activity.*

*\*Significantly different from SG and CG ( $p < 0.05$ ).*

## Results

Participants' characteristics are summarized in Table 1. No differences among groups in anthropometric, physical activity, nutritional and maturity status variables were observed. Futsal players had a lower number of training sessions ( $t = 13.3, p < 0.001$ ) and hours ( $t = 13.3, p < 0.001$ ) per week than swimmers. Regional aBMD and aBMC at all examined locations (BMD at the lumbar spine –  $F_{(2,67)} = 8.19, p = 0.001, \eta^2 = 0.21$ ; pelvis –  $F_{(2,67)} = 18.77, p < 0.001, \eta^2 = 0.38$ ; lower limbs –  $F_{(2,67)} = 16.01, p < 0.001, \eta^2 = 0.34$ ; and aBMC at the lumbar spine –  $F_{(2,67)} = 4.69, p = 0.013, \eta^2 = 0.13$ ; pelvis –  $F_{(2,67)} = 13.48, p < 0.001, \eta^2 = 0.30$ ; lower limbs –  $F_{(2,67)} = 17.76, p < 0.001, \eta^2 = 0.36$ ) were significantly higher in futsal athletes compared with those of swimmers and controls. No significant differences were noted in regional aBMD and aBMC variables between the SG and CG ( $p > 0.05$ ).

## Discussion

While previous studies have investigated the effects of weight-bearing sports on the bone mass of children and adolescents, the current study is the first that examined the bone mass of adolescent futsal players in comparison with swimmers and sedentary boys of the same age. We confirmed that adolescents engaged in a weight-bearing sport (futsal) had superior bone mass compared with swimmers and non-athletic adolescents, with aBMD and aBMC at all measured sites being higher in futsal players than in swimmers and control subjects.

These findings corroborate previous studies that indicated that weight-bearing and high-impact loading activities were effective forms of sport permitting optimizing bone mass during adolescence (Bailey et al., 1999; Calbet et al., 2001; Fredericson et al., 2007; Ginty et al., 2005; Grimston et al., 1993). These sport activities develop bone loading by two separate ways: one that occurs from high impact loads from sports; and an indirect osteogenic way, by the development of muscles in a specific area, making a higher tension on the bone attached to them (Rahnama et al., 2005; Vicente-Rodriguez, 2006). Thus, futsal produces a high stimulus in bones as it involves high-impact and odd-impact ground reaction forces applied to the play surface during

the development of different game actions, being suggested as beneficial to calcium deposition and bone modeling (Anliker et al., 2013; González-Aramendi, 2003; Hart et al., 2016). Considering the lack of a swimming effect on bone mass, our results suggest that muscle contractions generated during swimming do not exceed the minimum effective strain stimulus threshold to induce an osteogenic effect (Vlachopoulos et al., 2017), as observed in futsal players. Our results strongly suggest that impact is essential to induce bone mass adaptation, as the higher frequency and duration of swimming training sessions were insufficient to compensate the lack of a weight-bearing environment compared to futsal training. We also found similar aBMD and aBMC between swimmers and controls, which is in line with evidence from a recent meta-analysis of fourteen studies (Gomez-Bruton et al., 2016) and a recent cross-sectional study characterizing bone mass, bone geometry and bone remodelling activity in adolescent males (Vlachopoulos and Barker, 2017). The similarities observed in the current study between swimmers and controls are likely to be explained by the non-weight bearing environment during swimming and an insufficient amount and type of muscle contractions to produce bone adaptations. Although swimming is considered “non-osteogenic”, the supporting evidence is still unclear particularly when the hypothesis of a molecular “cross talk” between muscle and bone is currently supported (Tagliaferri et al., 2015). The contribution of non-mechanical (i.e., genetic and molecular) links between muscle and bone of sport participation should be explored in future studies. In opposition, in the practice of non-weight bearing and low-impact sports, as for example swimming, the bones do not receive so many stimuli, thus the bone formation (density and content) is significantly lower (Karlsson et al., 2008). Our study supports findings that weight-bearing sport activities are necessary to produce an increase in bone mass. This result is also confirmed by the lack of significant differences in any measure of aBMD and aBMC. Weight-bearing sports (e.g. football, basketball and handball) had a greater positive effect on bone mass, whereas others, such as swimming, actively use their muscular system, but does not have a direct loading impact on skeletal structures and

consequently, are negatively related to bone formation (Pedretti et al., 2016; Seabra et al., 2012, 2016; Ubago-Guisado et al., 2015).

In light of these findings, futsal should be considered as a sport with the potential to improve bone mass density and content during childhood and adolescence, since it activates a wide range of body muscles to fulfil the physical demands of the game (such as sudden changes of running speed, kicking the ball and corporal contacts against the opponent players (Krustrup et al., 2009). Furthermore, it involves a high number of jumps and other unorthodox movements requiring abrupt changes of the position of the body imposing impact on the bone and a consequent increase in its mineralization. Ginty et al. (2005) suggested that the practice of sports with a high mechanical load and corporal impact (like futsal) resulted in an increase of bone mass compared to activities where the body mass was little requested. Futsal players showed a higher bone mass at all skeletal sites compared to swimmers and control participants, which may have clinical relevance in terms of promoting bone health and help prevent future development of osteoporosis in adulthood.

However, the interpretation of current results should take into account certain

methodological limitations: (i) the cross-sectional nature of the research design adopted did not make possible to establish casual relationships. Thus, longitudinal analyses are needed in order to monitor the growth rate of bone variables and to describe the respective growth curves, which could help better understand the results found; and (ii) the limited number of participants might have reduced the statistical power for group comparisons and, in turn, the generalizability of the results. Nevertheless, the post hoc statistical power tests for detecting bone mass differences between three groups ranged from 81 to 99%.

In summary, the present findings showed that adolescent male futsal players involved in weight-bearing and high- and odd-impact activities had greater levels of aBMD and aBMC when compared to swimmers (a non-weight-bearing sport) and controls. Therefore, futsal should be considered as a promising public health strategy for healthy bone mass acquisition and development. These findings highlight the need for further research in the context of replication and potential translation into more pronounced benefits in larger-scale studies.

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