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## ORIGINAL

### EVALUATION OF BONE MINERAL DENSITY WITH DEXA IN YOUTH SOCCER PLAYERS

### EVALUACIÓN DE LA DENSIDAD MINERAL ÓSEA CON DEXA EN FUTBOLISTAS JUVENILES

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#### ABSTRACT

The objective of this study was to assess the bone mineral density (BMD) and bone mineral content (BMC) of body segments during a six-month training period. Two measurements were made, one at the start (IM) and one at the end (FM)

using dual-energy x-ray absorptiometry (DEXA) in 41 professional youth soccer players. A significant increase in BMD from IM to FM was found in the hip, lumbar spine, Ward triangle, trunk and total body ( $p<0.05$ ). In the BMC there was a significant increase in the hip, leg, trunk, lumbar spine and ribs ( $p<0.05$ ). Soccer training strengthens the bone of the lower areas and the rib cage with an increase in BMC, considering it as a tool for bone mineralization and strengthening to prevent injuries and fractures.

**KEYWORDS:** soccer, DEXA, bone, mineral, density.

## RESUMEN

El objetivo de este estudio fue evaluar la densidad mineral ósea (DMO) y el contenido mineral óseo (CMO) de los segmentos corporales durante un periodo de entrenamiento de seis meses. Se realizaron dos tomas de medición, una al inicio (TI) y otra al final (TF) a través de la absorciometría dual de rayos-x (DEXA) a 41 futbolistas juveniles profesionales. Se encontró un aumento significativo de la DMO de la TI a la TF en la cadera, columna lumbar, triángulo de Ward, tronco y el cuerpo total ( $p<0.05$ ). En el CMO hubo un aumento significativo en la cadera, columna lumbar, pierna, tronco y costillas ( $p<0.05$ ). El entrenamiento de fútbol fortalece al hueso de las zonas inferiores y de la caja torácica con el aumento del CMO, considerandolo como una herramienta para la mineralización y fortalecimiento del hueso, para prevenir lesiones y fracturas.

**PALABRAS CLAVES:** Fútbol, DEXA, hueso, mineral, densidad.

## INTRODUCTION

Exercise and sports during growth can accelerate bone mineral levels, providing adequate stimuli to bone and achieving strengthening and maintenance (Cervinka, Tiftweger, Hyttinen, Felsenberg and Sievänen, 2011; Creighton, Morgan, Boardley and Brolinson, 2001; Meyer et al., 2004; Quintas, Ortega, López-Sobaler, Garrido and Requejo, 2003) to prevent fractures at later ages (Christofferson et al. 2015). A high level of bone mass can be achieved by performing physical activity during adolescence and as a young adult (Van Langendonck et al., 2003), without forgetting that bone structure can also be altered by bone tissue metabolism, the individual's genetic predisposition, the behavior of the endocrine system (Oh et al., 2005), hormone control (Sun, Davies, Blair, Abe and Zaidi, 2006), and the consumption of some minerals such as calcium and phosphorus (Manuel Gomez, 2006).

Several studies in athletes or individuals with physical activity have discovered different effects that can cause bone mineralization or remodeling. Sports such as

tennis, volleyball and soccer, in which bone has an important burden or a high impact, usually have positive effects on bone mineralization (Kontulainen et al., 2001; Morel, Combe, Francisco and Bernard, 2001). However, sports such as cycling and swimming, which are mainly practiced with no bone mass burden because they do not support body weight or have a low impact on bone, usually do not have significant increases in bone mineral in the body (Söderman, Bergström, Lorentzon, and Alfredson, 2000; Milgrom et al., 2000).

Other sports that do not usually have a positive effect on bone mass are those of resistance such as marathons, race walking and long distance running (Calbet, Dorado, Diaz-Herrera, and Rodríguez-Rodríguez, 2001) where, due to the calorie intake deficit, athletes may not be meeting the necessary requirements of minerals, vitamins, and proteins, a situation that affects bone and causes a bone mineralization that may not be effective (Vicente-Rodríguez et al., 2004).

Soccer, characterized by different changes in direction, jumps, falls, starts and stops that greatly affect the lower part of the body due to the reaction force and movement, increases bone stimulation (Calbet et al., 2001). It has been justified that soccer players have a greater increase in bone mineral content (BMC) (Calbet et al., 2001; Vicente-Rodríguez et al., 2004) caused by physical activity in some areas of the body, since bone cells, especially the formation of osteoblasts, can behave differently in these areas, compared to areas without activity (Khan, 2001; Scott, Khan, Duronio and Hart, 2008). This is why it is considered a high impact, osteogenic sport (Calbet et al., 2001).

The objective of this study was to determine the bone mineral density (BMD) and the BMC of body segments (spine, hip, arms, legs, trunk, ribs, and total body) as well as the lumbar spine and the femoral area (neck, trochanter, and Ward triangle) during a six-month training period of young soccer players where two measures were made, one at the beginning and one at the end.

## **MATERIAL AND METHODS**

This was a longitudinal study of 41 athletes from a professional youth soccer team ( $15.85 \pm 0.98$  years of age), in which BMD and BMC were evaluated using dual-energy x-ray absorptiometry (DEXA) at the beginning and end of the six-month training period. The athletes provided written informed consent to perform the DEXA scan. Soccer players with no physical lesion at the start and during the assessment period were included in the study.

### *Anthropometry*

The anthropometric measurement protocol was performed by an individual (level III) certified by the International Society for the Advancement of Kinanthropometry

(ISAK) with techniques described in the manual of International Standards for Anthropometric Assessment (Stewart, 2010). The soccer players were scheduled early in the morning after an eight-hour fast and without having practiced any sport, and were weighed with a TBF-410 Tanita scale ( $0 - 200 \text{ kg} \pm 0.01 \text{ kg}$ ) and measured with a Seca 213 stadiometer ( $20 - 205 \text{ cm} \pm 5 \text{ mm}$ ). Afterwards, the body mass index (BMI) was obtained.

#### Dual-energy x-ray absorptiometry

BMD and BMC were carried out using a General Electric Bone Densitometer (GE Medical Systems Ultrasound & Primary Care Diagnostics LLC, Madison, WI) and enCORE LU43616ES software. The areas evaluated were the spine, hip, arms, legs, trunk, ribs, full body, lumbar spine (L1-L4), and the femoral area. Both arms and legs on the left and right side of the body were measured and the mean value of each side was recorded. The lumbar spine (L1-L4) was specified as the mean value of the spine at L1, L2, L3 and L4. The femoral area (neck, trochanter, and Ward triangle) was evaluated on the left and right side of the legs and the mean value was obtained for both.

BMD classification was provided by the software of the DEXA device in which the World Health Organization provides a BMD range as a T-score greater or equal to -1 as adequate calcification, between -1 and -2.5 as low osteopenia, and a score less or equal to -2.5 as osteoporosis.

#### Statistical analysis

The statistical analysis was performed using SPSS for Windows version 21.0. Descriptive statistics were used to describe the data: means and standard deviations for basic measurements (age, weight, height and BMI) and for BMD and BMC measurements of the body segments. Student's t-test was also used to determine the correlation between the initial measurement (IM) and the final measurement (FM) of the variables BMD and BMC of the body areas. A statistical level of  $p < 0.05$  was considered significant.

## RESULTS

The characteristics of the baseline measures of the study participants are shown in Table 1. Regarding body weight, a significant increase from IM to FM was found ( $p < 0.05$ ). With regard to BMI, there was also a significant increase from IM to FM ( $p < 0.05$ ), yielding a mean within normal weight in percentiles by age (5 - 85) (NCHS, 2000).

BMD increased from IM to FM in all body segments (Table 2), achieving a significant increase in the hip, the lumbar spine, the Ward triangle, the trunk, and the total body during the six months of training ( $p < 0.05$ ). Also, all BMD values from the IM and the FM were within the T-score as adequate in bone density (greater than or equal to -1).

The BMC values obtained showed a reduction from IM to FM of the trochanter (-1.34 g) and the arms region (-1.2 g) (Table 3). The other regions of the body had positive changes during the six-month training period with significant increases of the hip, lumbar spine, legs, trunk, and ribs ( $p < 0.05$ ).

## DISCUSSION

Measurement of bone structure, mainly BMD and BMC in athletes, is important for performance, health and to prevent future injuries. There are disciplines that have greater demands in performance or sports that have a high impact on bone due to the mechanical movements of the body. These usually produce changes in bone mineralization in a determined period of time, a situation that can be harmful or beneficial to the human skeleton. This is why the behavior of bone mineralization should be monitored during the training or competition period. Therefore, the objective of this study was to evaluate the BMD and BMC in body areas during a six-month training period in young soccer players.

There are sports that are considered low impact, such as cycling and swimming because of the negative osteogenic effect on bone, and there are high impact sports such as soccer, volleyball, gymnastics and weightlifting, which contribute to the development and maintenance of bone structure (Sherk et al., 2014). This theory shows that in some studies carried out in swimmers (Maïmoum et al., 2004) and cyclists (Abe et al., 2014) a low whole-body BMD was obtained in comparison with studies that were done in gymnasts (Hind, Gannon, Whatley, Cooke and Truscott, 2012), volleyball players (López-García, Hernández-Cruz, Rangel-Colmenero and García-Sánchez, 2015), weightlifters (Lafforgue, 2013), and as in our results, soccer players.

With regard to the BMD in different areas of the body, the region evaluated should be specifically identified because of the different mechanical burdens and technical movements performed during the practice of the sport that affect the human skeleton. In this study, the areas with the greatest BMD were the lower part of the legs, the Ward triangle, and the femoral neck. This was in contrast with the arms, where together with the ribs, the lowest BMD was found. These results are similar to several cross-sectional studies in sports such as soccer (Morel et al., 2001; Wittich, Oliveri, Rotember y Mautalen, 2001; McClanahan et al., 2002; Calbet et al., 2001), tennis, baseball, basketball and football (McClanahan et al., 2002).

High impact sports that produce a greater contact force in lower areas of the body such as soccer (Morel et al., 2001, Fredericson et al., 2007, Hinrichs, Chae, Lehmann, Allolio and Platen, 2010, Calbet et al., 2001; Hage, Jaber, Jacob, Moussa, and Theunynck, 2013; Silva, Goldberg, Teixeira and Dalmas, 2011) and combat sports (Hinrichs et al., 2010), obtained a greater BMD in the lumbar spine and femoral neck than in low impact sports such as runners (Fredericson et al., 2007), cycling (Hinrichs et al., 2010), triathlon (Hinrichs et al., 2010), swimming (Silva et al., 2011) and tennis (Silva et al., 2011), since these sports produce muscle tension movements without having an impact on bone. These results are reflected in our study since during the six-month training period, significant increases in the lumbar spine and Ward triangle were found ( $p < 0.05$ ).

Longitudinal studies on the evaluation of BMC in sports such as volleyball, basketball and softball in which total body increases were found have been reported in the literature (Carbuhn, Fernandez, Bragg, Green, y Crouse, 2010). These results are very similar to our study which reported increases during the six-month training period, but it is important to consider that this population had a mean age of  $15.85 \pm 0.98$  years, a stage in which there is still body growth and in which the BMC can continue to increase due to the growth and development of bone.

## CONCLUSIONS

One of the most important findings in this study after six months of evaluation, was that the legs had significant increases ( $p < 0.05$ ). This is because soccer largely affects the skeleton, mainly the lower part of the body due to the different mechanical movements, such as jumps, changes in directions, and the intensity of the sport (Calbet et al., 2001). This means that long-term training will strengthen the BMD of all the evaluated areas and that the lower part of the body will have benefits in the BMC in soccer players.

**Table 1.** Basic measurements of study participants from IM to FM.

	Basic measurements			
	IM	FM	Difference	t
Height (cm)	172.02 ± 7.48	172.02 ± 7.48		
Weight (kg)	65.60 ± 7.20	66.25 ± 7.34	0.65	-2.078*
BMI (kg/m <sup>2</sup> )	22.13 ± 1.57	22.34 ± 1.51	0.21	-2.087*

cm: centimeters; kg: kilograms; BMI: body mass index; kg/m<sup>2</sup>: kilograms per square meters; IM: initial measurement; FM: final measurement.

\* $p \leq 0.05$

**Table 2.** BMD measurements of study participants from IM to FM.

	BMD (g/cm <sup>2</sup> )			
	IM	FM	Difference	t
Spine	1.12 ± 0.11	1.14 ± 0.11	0.02	-1.644
Hip	1.32 ± 0.10	1.34 ± 0.11	0.02	-3.180*
Lumbar spine	1.27 ± 0.11	1.28 ± 0.11	0.01	-2.404*
Femoral neck	1.35 ± 0.13	1.48 ± 0.97	0.13	-0.883
Trochanter	1.18 ± 0.15	1.19 ± 0.10	0.01	-0.680
Ward triangle	1.33 ± 0.15	1.35 ± 0.16	0.02	-4.782*
Arms	0.95 ± 0.09	1.00 ± 0.18	0.05	-1.948
Legs	1.48 ± 0.09	1.49 ± 0.13	0.01	-0.703
Trunk	1.12 ± 0.09	1.16 ± 0.14	0.04	-2.493*
Ribs	0.86 ± 0.08	0.87 ± 0.08	0.01	-2.730
Total	1.32 ± 0.08	1.34 ± 0.08	0.02	-6.635*

BMD: bone mineral density; g/cm<sup>2</sup>: grams per square centimeter; IM: initial measurement; FM: final measurement.

\* $p \leq 0.05$

**Table 3.** BMC measurements of study participants from IM to FM.

	BMC (g)			
	IM	FM	Difference	t
Spine	176.3 ± 36.60	178.6 ± 39.05	2.3	-1.153
Hip	444.5 ± 62.65	455.4 ± 60.26	10.8	-3.746*
Lumbar spine	74.4 ± 14.86	75.7 ± 14.36	1.2	-2.026*
Femoral neck	7.09 ± 0.95	7.09 ± 1.39	0	-0.004
Trochanter	19.31 ± 12.00	17.97 ± 3.36	-1.34	0.706
Ward triangle	4.20 ± 0.78	4.28 ± 0.72	0.08	-1.550
Arms	357.5 ± 54.04	356.3 ± 76.45	-1.2	0.156
Legs	1245 ± 157.4	1259 ± 165.5	13.9	-4.620*
Trunk	861.2 ± 136.9	880.3 ± 136.3	19.1	-4.402*
Ribs	240.3 ± 52.35	246.2 ± 52.34	5.9	-2.326*
Total	2947 ± 378.1	2992 ± 382.5	45.8	-1.081

BMC: bone mineral content; g: grams; IM: initial measurement; FM: final measurement.

\* $p \leq 0.05$

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