Apunts Med Esport. 2015;50(188):129–137

apunts
MEDICINA DE L'ESPORT
www.apunts/org

ORIGINAL ARTICLE

# Relationship of chronological age and sexual maturity with skeletal maturity by magnetic resonance imaging of the distal radial epiphysis in adolescent football players

Jesús Bolívar[a,b], Óscar Sandoval[c], Jorge Osorio[a,b], Gabriel Dib[d], Jaime Gallo[a,b,e,*]

[a] *Faculty of Medicine, University of Antioquia, Medellín, Colombia*
[b] *Research Group in Medicine Applied to Physical Activity and Sport – GRINMADE, University of Antioquia, Medellín, Colombia*
[c] *University Hospital of Neiva, Neiva, Colombia*
[d] *Advanced Centre of Diagnostic Medicine (CEDIMED), Medellín, Colombia*
[e] *Clinical and Research Centre (SICOR), Medellín, Colombia*

Received 3 February 2015; accepted 25 May 2015
Available online 29 June 2015

**KEYWORDS**
Age determination by skeleton;
Sexual development;
Adolescent;
Magnetic resonance imaging;
Epiphysis;
Football

**Abstract**
*Introduction:* Although the grade of fusion of the left distal radial epiphysis (LDRE) observed by magnetic resonance imaging (MRI) has been linked to chronological age (CA), its relationship to Tanner stage of the genitals in the Latin American population is unknown.
*Objective:* To evaluate the relationship of CA and sexual maturity with skeletal maturity (SM) determined by MRI of the LDRE in adolescent football players from Medellin, Colombia.
*Materials and methods:* Cross-sectional study that included 60 male football players with certified legal age between 12 and 18 years. Medical evaluation and MRI of the LDRE using a 1.5 T scanner was performed according to a described protocol. The image reading was performed by 3 blinded evaluators. SM was classified as: A: immature; B: developing; C: mature, and inter- and intra-observer variability was assessed.
*Results:* Among the football players included in the study, the average body mass index and body fat were $19.6 \pm 2.0\,kg/m^2$ and $11.1 \pm 1.2\%$, respectively. A correlation of CA and the Tanner stage of genital maturity with SM (Kendall's Tau_b 0.686 and 0.693, respectively; $P < .001$) was found. All players classified as stage C were 17 or older and Tanner stage V. The inter-observer and intra-observer agreement showed a *kappa index* of 0.36 ($P < .001$) and 0.60 ($P < .001$), respectively.

* Corresponding author.
*E-mail address:* jagallo2000@yahoo.com (J. Gallo).

http://dx.doi.org/10.1016/j.apunts.2015.05.002

*Conclusion:* A relationship was found between CA and sexual maturity and SM by MRI of the LDRE in adolescent football players. Classification by stage of SM in 3 categories could be more practical and have implications for competition.


**PALABRAS CLAVE**
Determinación de la edad por el esqueleto;
Desarrollo sexual;
Adolescente;
Imagen por resonancia magnética;
Epífisis;
Fútbol

**Relación de la edad cronológica y la maduración sexual con la maduración ósea por resonancia magnética nuclear de la epífisis del radio distal en futbolistas adolescentes**

**Resumen**
*Introducción:* Aunque el grado de fusión de la epífisis del radio distal izquierdo (ERDI) por resonancia magnética nuclear (RMN) se ha relacionado con la edad cronológica (EC), se desconoce su relación con el Tanner genital en población latinoamericana.
*Objetivo:* Evaluar la relación de la EC y la maduración sexual con la maduración ósea (MO) por RMN de la ERDI en futbolistas adolescentes de la ciudad de Medellín, Colombia.
*Materiales y métodos:* Estudio transversal que incluyó 60 futbolistas hombres con edad legal certificada entre 12 y 18 años. Se realizó una evaluación médica y una RMN de la ERDI con un resonador de 1.5 T según un protocolo descrito. La lectura de la imagen fue realizada por 3 evaluadores cegados. Se determinó la MO en tres estadios (A: inmaduros; B: en desarrollo; C: maduros) y se evaluó la variabilidad inter e intra-observador.
*Resultados:* Entre los futbolistas incluidos, se encontró un promedio de índice de masa corporal y porcentaje de grasa corporal de $19{,}6 \pm 2{,}0$ Kg/m$^2$ y $1{,}1 \pm 1{,}2$%, respectivamente. Se encontró correlación de la EC y el estadio de maduración por Tanner genital con la MO (Tau_b de Kendall 0,686 y 0,693, respectivamente; $p < 0{,}001$). Todos los jugadores clasificados en el grado C tenían 17 o más años y Tanner estadio V. La concordancia inter-observador e intra-observador, mostró un índice *kappa* de 0,36 ($p < 0{,}001$) y 0,60 ($p < 0{,}001$), respectivamente.
*Conclusión:* Se encontró relación de la EC y la maduración sexual con la MO por RMN de la ERDI en futbolistas adolescentes. La clasificación por grados de MO en 3 categorías, podría ser más práctica y tener implicaciones para la competencia.


## Introduction

In the lower divisions of Colombian and international football leagues, misconduct has been described that falsifies and/or supplants identity documents to integrate older individuals into sports participation by claiming a younger age. Some of these players are perceived as talented players, when in reality, they are more mature individuals than appropriate for the divisions.[1,2]

The available methods for determining bone age based on X-ray studies are imprecise and not validated in our population[3]; currently, screening procedures using X-rays are inadequate, and research studies are prohibited from using this type of technique.[4]

Studies conducted at the Centre for Medical Research and Assessment of the International Federation of Association Football (FIFA, for its initials in French) show that Magnetic Resonance Imaging (MRI) of the left distal radial epiphysis (LDRE) can be used to determine the grade of skeletal maturity (SM) more dependably than X-ray techniques.[5] In the validation study of the method, a classification scheme of 6 progressive grades was described (I–VI), according to the fusion of the LDRE in male football players between 14 and 19 years old in four different areas of the world (Switzerland, Algeria, Malaysia and Argentina).[5] In this study involving 496 players, it was found that between 16 and 17 year olds, less than 1% had complete fusion, and at 19 years, 100% were completely fused. It was concluded that this method of evaluating the grade of SM by MRI of the LDRE is accurate, reliable, and reproducible. It also offers a non-invasive alternative for assessing the SM of players.

In addition, the same FIFA research group reported results from evaluating SM of the LDRE by MRI in 189 participating players in 4 international Sub-17 competitions (FIFA 2003 World Cup Sub-17 Finland, FIFA 2005 World Cup Sub-17 Peru, Asian Football Confederation AFC Sub-17 2004 Japan, AFC Sub-17 2006 Singapore). In this study, there was a lack of correlation between reported age and grade of fusion, which suggested that the players of these competitions were more mature than the reference population and reinforced suspicion that the age declared in official documents was not correct in all cases.[6]

The average age according to the grade of fusion of the LDRE by MRI can vary in different regions.[5] The Colombian