



ARTICLE ORIGINAL / RESEARCH ARTICLE

Estimation of bone age by MRI and inter-observer variability for a Cameroonian “Fifa u-17” pre-selection.

Estimation de l'âge osseux par IRM et variabilité inter-observateur pour une pré-sélection Camerounaise « Fifa u-17 ».

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RÉSUMÉ

Background: The chronological age of Cameroonian footballers has often been difficult to verify as registration at birth is not compulsory and documentation of births is not proper and unreliable. Hence, an accurate method of age determination for age-related competitive sports is important.

Objective: To determine the actual age of Cameroonian football players aspiring to play for the national U17 football, using the degree of fusion of the distal radius on Magnetic Resonance Imaging (MRI) and evaluate the inter-observer reliability between the raters.

Methods: We interpreted MRI scans of the left wrist of 89 players selected to play for the national U 17 during the 2019 and 2021 African Cup of Nations (AFCON) organized by FIFA. The study was carried out at an imaging centre in Yaoundé. All images were obtained on a 1.5T MRI Scanner and analyzed by three independent raters using the previously published FIFA grading system.

Results: The mean declared age of the players was 15.7±1.1. The mean age on MRI scans was 17.04. There was no significant correlation between the declared ages and the bone ages of the players (Spearman rho, r=0.152). The inter-observer reliability for grading was high (r=0.86, 0.89 and 0.94).

Conclusion: MRI of the left wrist is an accurate method of age determination and selection of players in age-related competitive sports. The lack of correlation between declared age and bone age supports the suspicion that most Cameroonian football players may not know their real ages or may have falsified them. The very high inter-observer variability validates the reliability and reproducibility of this method of bone age estimation.

ABSTRACT

Background: L'âge chronologique des footballeurs camerounais a souvent été difficile à vérifier car l'enregistrement à la naissance n'est pas obligatoire et les documents de naissance ne sont pas toujours authentifiables et donc peu fiables. Il est donc important de disposer d'une méthode précise de détermination de l'âge pour les sports de compétition liés à l'âge comme le football.

Objectif: Déterminer l'âge réel des footballeurs camerounais aspirant à jouer pour la sélection nationale de football U17, en utilisant le degré de fusion de la physe radiale distal en Imagerie par Résonance Magnétique (IRM) et évaluer la fiabilité inter-observateur entre les évaluateurs.

Méthode: Nous avons interprété les examens IRM du poignet gauche de 89 joueurs sélectionnés pour jouer pour la sélection nationale U 17 lors de la Coupe d'Afrique des Nations (AFCON) 2019 et 2021 organisée par la FIFA. L'étude a été réalisée dans un centre d'imagerie à Yaoundé. Toutes les images ont été obtenues sur un scanner IRM 1,5T et analysées par trois évaluateurs indépendants à l'aide du système de notation FIFA précédemment publié.

Résultats: L'âge moyen déclaré des joueurs était de $15,7 \pm 1,1$. L'âge moyen à l'IRM était de 17,04 ans. Il n'y avait pas de corrélation significative entre les âges déclarés et l'âge osseux des joueurs (Spearman rho, $r=0,152$). La fiabilité inter-observateur pour la notation était élevée ($r = 0,86, 0,89$ et $0,94$).

Conclusion: L'IRM du poignet gauche est une méthode précise de détermination de l'âge et de sélection des joueurs dans les sports de compétition liés à l'âge. L'absence de corrélation entre l'âge déclaré et l'âge osseux conforte la suspicion selon laquelle la plupart des footballeurs camerounais ne connaissent peut-être pas leur âge réel ou l'ont falsifié. La très forte variabilité inter-observateur valide la fiabilité et la reproductibilité de cette méthode d'estimation de l'âge osseux.

1. Introduction

Age can be estimated through somatic features that are universally considered associated with chronological age despite the fact that these features do not always coincide with the real chronological age⁽¹⁾. Bone age is often used as an indicator of the skeletal and biological maturity of an individual and its evaluation is a common procedure frequently performed in clinical practice. Often requested by pediatricians and endocrinologists, bone age can be compared with chronological age for diagnosing diseases which result in tall or short stature in children^(2, 3).

Standard radiographs of the left wrist have been widely used in the assessment of skeletal age. However, the International Atomic Energy Agency (IAEA) strongly discourages the use of ionizing radiation without clinical justification. It recommends the use of other imaging methods if they can provide the same or more information⁽⁴⁾. Magnetic Resonance Imaging (MRI) is a noninvasive and relatively new method of bone age assessment⁽⁵⁾.

Cameroon's civil registration suffers appropriate and reliable documentation in most parts of the country, hence a source of manipulation and an increased likelihood of erroneous ages. According to the latest United Nations International Children's Emergency Fund (UNICEF) estimations, about 51 million births go unregistered in developing countries each year⁽⁶⁾. Given that performance during sports competitions can be influenced by age, metabolic, genetic and social factors⁽⁶⁻⁸⁾, it is

therefore important to know the exact ages especially in the sporting environment.

Accurate age determination is very important in age-related competitive sports. Inconsistencies in age can lead to sanctions that range from fines to disqualification from the games and even subsequent ones. It also discourages fair play. The study was aimed at determining the relationship between the declared ages of eligible under-17 selected football players and their bone ages on MRI by using the Federation Internationale de Football Association (FIFA) MRI grading, and to evaluate how reproducible the results of bone age are over time, and how repeatable by different individuals (inter-observer variability) the estimations are.

2. Matériels et Méthodes

We carried out a cross sectional, descriptive and analytic study involving MRI scans of the left wrist of 89 players aspiring to play for the national U17 football team during the 2019 and 2021 AFCON tournaments. All the participants irrespective of their chronologic ages were recruited, but for those with a history of joint trauma or surgery, known hormonal or metabolic diseases and those who were eligible for 2019 selection, to avoid counting twice.

MRI Scanning Protocol

All scans were performed on a TOSHIBA 1.5T MRI scanner. The players were placed in prone position with the wrist above the head. The third metacarpal was placed as close as possible to the same axis as the radius. Coronal sequences were obtained. The

images obtained were saved to allow evaluation on a Picture Archiving and Communications System (PACS). Table 1 below is a summary of the characteristics of the MRI equipment used.

Table I: Characteristics of the MRI equipment in the study

Parameter	Description
MRI scanner	TOSHIBA
Magnetic field strength	1.5 Tesla
Magnet type	Permanent
Type of coil	Wrist
Protocol for left wrist (bone age determination)	Coronal
Repetition time (TR)	500ms
Echo time (TE)	12ms
Frequency	256Hz
Phase number	224
Total number of images	14
Slice thickness	3mm
Inter-slice gap	0.3mm
Field of view	120mm.

The study was carried out at Centre Médicale la Cathédrale in Yaoundé. The degree of fusion of the left distal radial physis was determined by a team comprising of 2 consultant radiologists and a senior radiology resident. The images were concurrently analyzed using the previously published FIFA grading system^(9,10).

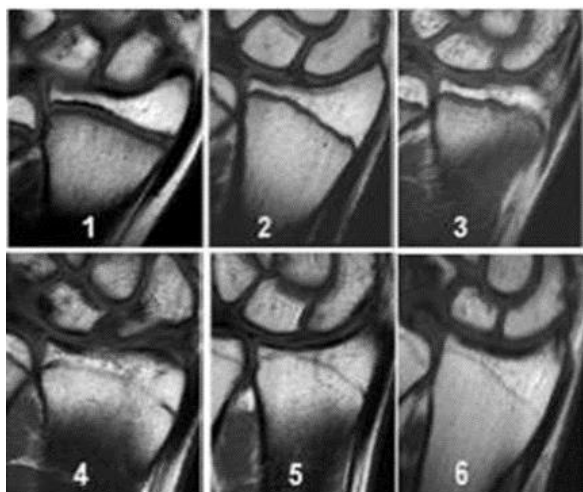


Figure 1: Classification for grades I–VI for fusion of the physis of the distal left radius(12).

MRI grading system:

Grade I: Completely unfused

Grade II: Early fusion: minimal hyperintensity within the physis

Grade III: Trabecular fusion of <50% of the radial cross sectional area

Grade IV: Trabecular fusion of >50% of the radial cross sectional area

Grade V: Residual physis, 5 mm on any one section

Grade VI: Completely fused

Statistical methods: Data were processed using Microsoft Excel, and statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 17.

Frequencies were obtained for all variables after grouping. Frequency tables were exported to Microsoft Excel 2010 to draw charts. The study population was appropriately described according to age groups using frequency tables.

The grade of fusion by MRI and the actual age at MRI examination were cross-tabulated and presented as counts and percentages.

Correlation between declared age and grade of fusion was calculated using the Spearman rho. Inter-observer agreement was calculated using the Cohen Kappa with values ranging from 0 (no agreement) to 1 (very strong agreement).

3. Résultats

Age: A total of 89 players with declared ages between 13 and 20 years presented for MRI scan of the left wrist. The mean age of the players was 15.7 years (SD \pm 1.1). Table 2 below shows the distribution according to declared age.

Table II: Distribution according to declared age

Age (years)	Frequency (n)	Percentage (%)	Mean \pm SD
13	1	1.1	15.7 \pm 1.15
14	13	14.6	
15	24	27	
16	29	32.6	
17	20	22.5	
18	1	1.1	
20	1	1.1	

Table III: Distribution in each grade of fusion

Grade	Frequency (n)	Percentage (%)
Grade I	5	5.6
Grade II	14	15.7
Grade III	4	4.
Grade IV	11	12.4
Grade V	32	36.0
Grade VI	22	24.7
Total	89	100.0

Degree of fusion: The majority of the players (54; 73.1%) were aged between 17 and 18 years. A cross tabulation of declared ages and degree of fusion

(**Table 3**) suggests that 25.8% of the players had a concordance between their declared age and MRI bone age (Figures 2, 3, 4, 5).

There was no significant correlation between declared age and degree of fusion (Table 4).

Inter-rater agreement: The level of agreement amongst the three raters was determined by Cohen Kappa coefficient. A Kappa value of 0.94 between the raters 1 and 2; 0.86 between raters 1 and 3; and 0.89 between raters 2 and 3 was recorded, indicating a very strong agreement.

Table IV: Cross tabulation between declared age and grade of fusion

n(%)	13	14	15	16	17	18	20	Total
Grade I	0(0)	1(1.1)	3(3.4)	0(0)	1(1.1)	0(0)	0(0)	5(5.6)
Grade II	0(0)	4(4.5)	4(4.5)	4(4.5)	2(2.2)	0(0)	0(0)	14(15.7)
Grade III	0(0)	1(1.1)	1(1.1)	2(2.2)	0(0)	0(0)	0(0)	4(4.5)
Grade IV	1(1.1)	1(1.1)	3(3.4)	3(3.4)	2(2.2)	1(1.1)	0(0)	11(12.4)
Grade V	0(0)	2(2.2)	7(7.9)	11(12.4)	11(12.4)	0(0)	0(0)	31(34.8)
Grade VI	0(0)	4(4.5)	6(6.7)	9(10.1)	9(10.1)	0(0)	1(1.1)	24(27.0)
Total	1(1.1)	13(14.6)	24(27.0)	29(32.6)	29(32.6)	1(1.1)	1(1.1)	89(100)

Spearman rho $r = 0.152$, $p = 0.15$

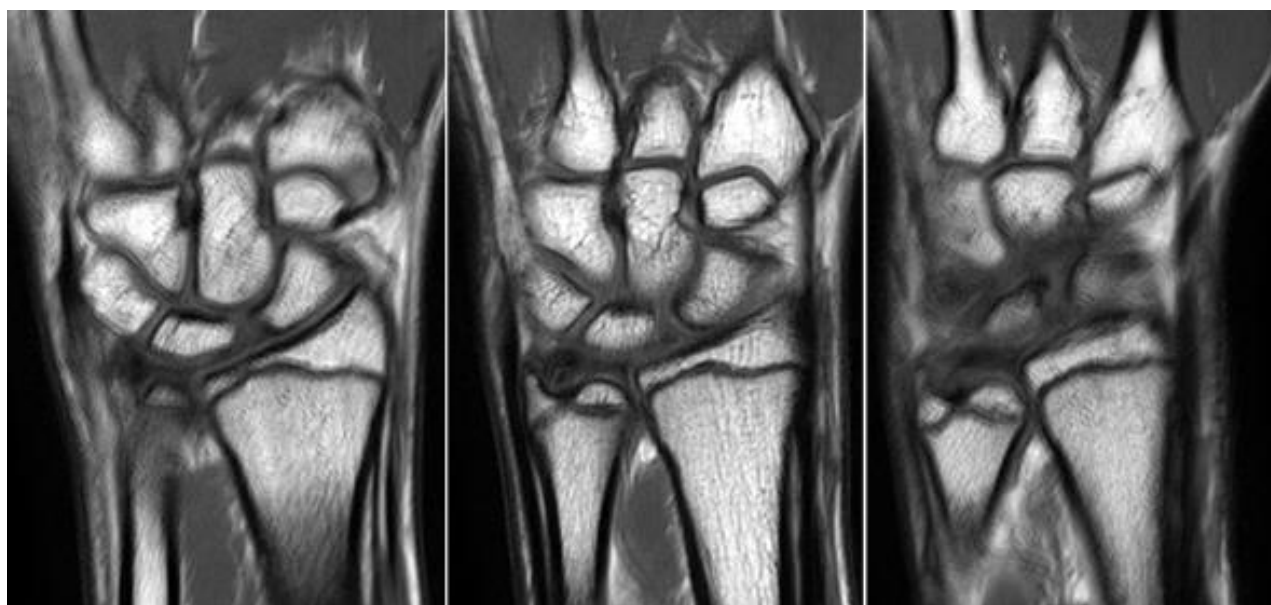


Figure 2: Estimated birth age from date of birth declared : 13 years and 11 months and 30 days. Bone age according to the method of Dvorak J et al ≈ 16.29 years : stage II.

Âge natal estimé à partir de la date de naissance déclarée : 13 ans et 11 mois et 30 jours. Âge osseux selon la méthode de Dvorak J et al $\approx 16,29$ ans stade II.



Figure 3: Estimated birth age from the date of birth declared : 16 years and 8 months and 04 days. Bone age according to the method of Dvorak J et al ≈ 16.78 years : stage III.

Âge natal estimé à partir de la date de naissance déclarée : 16 ans et 8 mois et 04 jours. Âge osseux selon la méthode de Dvorak J et al $\approx 16,78$ ans stade III.



Figure 4: Estimated birth age from the date of birth declared : 16 years and 02 months and 16 days. Bone age according to the method of Dvorak J et al ≈ 17.21 years : stage IV.

Âge natal estimé à partir de la date de naissance déclarée : à 16 ans et 02 mois et 16 jours. Âge osseux selon la méthode de Dvorak J et al $\approx 17,21$ ans stade IV.

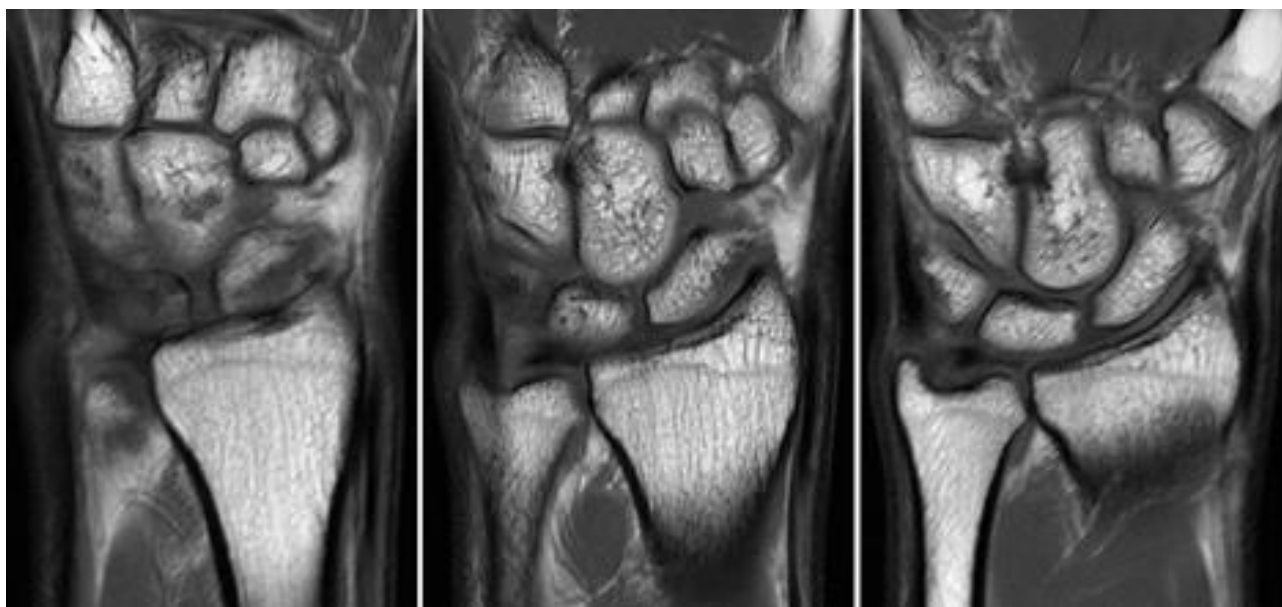


Figure 5: Estimated birth age from the date of birth declared : 15 years and 03 months and 25 days. Bone age according to the method of Dvorak J et al \approx 18.27 years : stage VI.
 Âge natal estimé à partir de la date de naissance déclarée : 15 ans et 03 mois et 25 jours. Âge osseux selon la méthode de Dvorak J et al \approx 18,27ans stade VI.

4. Discussion

The mean declared age of our players was 15.7 ± 1.1 years, with a minimum age of 13 years and a majority of players between 15 (27%) and 16 (32.6%) years. This was similarly obtained by Sarkodie et al in Ghana (5). The youngest player in our study was 13 years old, similar to that obtained in other studies⁽¹⁰⁻¹²⁾.

Our study found that a majority of players (73.1%) were between grades IV and VI, hence 17 years or older. This finding is similar to 71% obtained by Dvorak et al⁽¹⁰⁾ in 2007. This finding is however higher than what was obtained in other studies^(5, 13). The similarity could be explained by the fact that the study involved players from several countries some of which have no compulsory birth registrations, hence the possibility of erroneous or falsified ages.

Just 25.8% (n=25) of the players were graded between I and III, thus less than 17 years old. This finding is far less than what is described in other studies^(10, 12). This supports the suggestion that most players may not know their true ages or may have falsified them.

We equally found that 27% (n=24) of the players were graded VI that is with completely fused distal radius or over-age. Similar results were obtained in a Meta-analysis⁽¹⁰⁾ for the FIFA under-17 tournament in Europe. However it was less than that obtained in a study in Africa, where about 45% of the players were graded VI with a completely fused distal radius⁽¹²⁾ in which their study subjects were players of 3 different countries, hence a higher probability of erroneous or falsified ages.

There was no significant correlation observed in our study between declared age and grade of fusion ($r=0.152$, $p=0.15$). Our findings were consistent with that obtained in previous studies in Europe, Asia and Africa^(5, 10, 13). It was however different from that obtained in a study in Egypt (13) which found a moderate correlation between actual age (bone age) and grade of fusion.

Our study found that there was a strong inter-observer agreement between the raters, ($k=0.940$ between observers 1 and 2, $k=0.867$ between observers 1 and 3, and $k=0.896$ between observers 2 and 3). This was similar to what was obtained in other studies^(5, 11). MRI of the left wrist is therefore a reliable, radiation free method of age determination.

5. Conclusion

More than two-thirds (73%) of aspiring young male Cameroonian footballers are 17 years or older on MRI of the left wrist. The absence of correlation between declared age and MRI bone age supports the suspicion that most Cameroonians either do not know their real age or may have falsified them. The strong agreement between the raters validates the method of age determination as a reliable and reproducible one for males in the sporting environment.

Conflict of interest

The authors declare that they have no conflict of interest

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