ORIGINAL ARTICLE

Application of MRI of the wrist for age determination in international U-17 soccer competitions

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Background: To guarantee equal chances for different age groups, age-related tournaments for male and female players have been established in soccer. However, as registration at birth is not compulsory in some countries, other methods of age determination are needed to prevent participation in the incorrect age group.

Objectives: To evaluate the age of soccer players of international U-17 competitions from the degree of fusion of the distal radius and to compare the findings with an age-related normative population.

Methods: MRI scans of the wrist of a representative sample of 189 players from four U-17 competitions (FIFA U-17 World Cups 2003 and 2005, and Asian (AFC) U-17 championships 2004 and 2006) were analysed using a previously published grading system.

Results: Because of different regulations, all players in the AFC U-17 championships were younger than 17 years, whereas 71% of the players in the FIFA U-17 World Cup competitions were 17 years old. The distal radius of 15% of players from the AFC U-17 tournaments and 27% of the players from the FIFA U-17 tournaments were graded as completely fused on the MRI scans, which is a substantially higher percentage than in the respective age groups of a previously published normative population of soccer players. Furthermore, in contrast with the normative population, no significant correlation between the age category and the fusion grading ($r = 0.13$) was observed in U-17 players.

Conclusion: From the MRI results, U-17 soccer players seem to be more mature than a normative population of the same age category. However, the lack of correlation between age category and degree of fusion in U-17 players supports the suspicion that the age stated in the official documents of the U-17 players examined might not be correct in all cases.

In most sports, the performance of adolescent athletes is determined by their physical maturity and is thus related to age. Malina *et al*¹ examined maturity-associated variation in sport-specific skills of youth soccer players concluding that age, experience, body size and stage of puberty contribute significantly in different combinations to the variation in some soccer skills such as dribbling and passing, controlling the ball with the body, and shooting accuracy. Also players with a greater relative (or possibly false lower) age are more likely to be identified as "talented" because of the likely physical advantages they have over their "younger" peers.² To guarantee equal chances for different age groups, age-related tournaments for male and female players have been established in soccer. However, as registration at birth is not compulsory in some African and Asian countries, other methods of age determination are needed to prevent participation in the incorrect age group.

Standard radiography of the left wrist for assessment of skeletal age has been described by Todd,³ Greulich and Pyle,⁴ Tanner *et al*⁵ and Roche *et al*,⁷ who used the Fels method which is still widely used for assessment of skeletal age. Whereas standard radiographs with the attendant radiation risks cannot be justified as the screening tool for soccer populations, age estimation on the basis of grading of fusion of the distal radius using MRI has recently been shown to be a reliable and valid method in 14–19-year-old soccer players.⁸

In a previous study,⁸ 496 healthy male adolescent soccer players between the ages of 14 and 19 from Switzerland, Malaysia, Algeria, and Argentina had an MRI examination of the left wrist, and a newly developed grading system was applied to determine the degree of epiphyseal fusion of the radius. The inter-rater reliability for grading was high. The average age increased with higher grade of fusion, and the

correlation between age and grade of fusion was highly significant. Only one player (0.77%) from the 16-year-old age group was graded as having a completely fused radius and therefore as mature. The authors⁸ concluded that MRI of the wrist offers an alternative non-invasive method for age determination of male adolescents, and the grading system identified the skeletal maturity by complete fusion in all MRI slices, which eliminates the radiation risk associated with standard radiographs.

The aims of the study were:

- To evaluate the age of a representative sample of soccer players from international U-17 competitions (Fédération Internationale de Football Association (FIFA) and Asian Football Confederation (AFC)) using MRI scans of the wrist
- To compare the MRI findings for the players of U-17 competitions with an age-related normal population.

METHODS

Players from four U-17 competitions (2003 FIFA U-17 World Cup in Finland, 2004 AFC U-17 championship in Japan, 2005 FIFA U-17 World Cup in Peru, 2006 AFC U-17 championship in Singapore) were included in the study.

MRI scans were performed in the countries in which the tournaments took place according to parameters previously used to determine normative values (1.0 or 1.5 T magnet, dedicated wrist coil, coronal T_1 -weighted spin-echo images).⁸ The images were stored, where possible, electronically in the

Abbreviations: FIFA, Fédération Internationale de Football Association; AFC, Asian Football Confederation

Table 1 Classification criteria for ossification/fusion of the distal radius on MRI images⁸

I: completely unfused
II: early fusion; minimal hyperintensity within physis
III: trabecular fusion of less than 50% of radial cross-sectional area
IV: trabecular fusion of more than 50% of radial cross-sectional area
V: residual physis less than 5 mm on any one section
VI: completely fused

DICOM format, in order to allow evaluation electronically on a picture archiving and communication system.

The degree of fusion of the distal radius was graded independently by three raters using a previously published grading system⁸ (table 1).

The raters (three of the four authors) were blinded with regard to the name, age, and country of origin of the players as well as the country in which the competition was held. Two raters were experienced radiologists, and one an experienced neurologist with extensive experience in imaging. The blinding code was prepared by the fourth author (epidemiologist). The three individual gradings were computed to a majority grading using the most common grading or, if all three ratings deviated, the average grading.

Population

In both FIFA and the first AFC U-17 competitions (2003 FIFA U-17 World Cup in Finland, 2004 AFC U-17 championship in Japan, 2005 FIFA U-17 World Cup in Peru), three players from each of the 16 participating teams were randomly selected for examination.

In the 2006 AFC U-17 championship, a specially trained AFC doctor selected three players from each of the 16 teams on the basis of anthropometric data (height, body mass index). With this approach, the AFC competition department aimed to select the most mature appearing players in each team. Before this tournament, AFC had advised the team managers that MRI would be performed to detect players with complete fusion of the distal radius and proposed that each country should perform its own screening before registering players for participation.

Statistical analysis

All data were processed on a Macintosh computer (Apple Computer; Cupertino, California, USA) using Microsoft Excel (Microsoft Corp, Redmond, Washington, USA). The statistical procedures were performed using StatView (V5.0; SAS Institute, Cary, North Carolina, USA). The statistical methods

Figure 1 Age distribution of players in the FIFA and AFC U-17 competitions. FIFA, Fédération Internationale de Football Association; AFC, Asian Football Confederation.

applied were frequencies, cross-tabulations and Spearman's (ρ) rank correlation.

RESULTS

In total, 189 players were examined during the four U-17 competitions; 48 players from each of the 2003 FIFA U-17 World Cup in Finland, the 2004 AFC U-17 championship in Japan and the 2006 AFC U-17 championship in Singapore, and 45 players from the 2005 FIFA U-17 World Cup in Peru. In the last of these, three players from one team could not be examined for logistic and technical reasons.

Figure 1 shows the distribution of ages in the AFC and FIFA competitions. In the AFC competitions, all players were under 17 years of age according to their documents, whereas in the FIFA competitions 71% ($n = 66$) were 17 years old.

Table 2 presents the distribution of the degree of fusion in the four U-17 tournaments and age-related values from a normative population.⁸ Fourteen players (15%) in the AFC competition had complete fusion of the distal radius (grade VI), and in the FIFA competition 25 players (27%) with complete fusion of the distal radius were found. The respective values of the normative population were less than 1% of under 17-year-old players and 10% of 17-year-old players.⁸ The frequency of players with completely fused wrists decreased from the first to the second competition (FIFA, from 2003 to 2005; AFC, from 2004 to 2006). However, in all four U-17 competitions, more players had the two highest degrees of fusion (grade V and VI) than in the age-related normative population (AFC, 48% vs 14%; FIFA, 61% vs 37%).

Figure 2 shows the distribution of grades of fusion in different age groups for players in the U-17 competitions and the normative population.⁸ Eight players in the AFC U-17 championships were 14 years old according to their documents; in three cases, the fusion of the distal radius was graded as VI and in two

Table 2 Distribution of the grade of fusion in the four U-17 competitions and in the different age groups of a normative population⁸

Grade of fusion	FIFA U-17		AFC U-17		Normative population ⁸		
	Finland 2003	Peru 2005	Japan 2004	Singapore 2006	16-17	17-18	18-19
I	7 (15)	0	3 (6)	0	16 (12)	5 (4)	0
II	11 (23)	4 (9)	11 (23)	5 (10)	65 (50)	37 (32)	5 (6)
III	3 (6)	5 (11)	4 (8)	6 (13)	16 (12)	10 (9)	8 (9)
IV	2 (4)	4 (9)	9 (19)	15 (31)	15 (11)	21 (18)	13 (15)
V	8 (17)	24 (53)	10 (21)	19 (40)	17 (13)	31 (27)	49 (58)
VI	17 (35)	8 (18)	11 (23)	3 (6)	1 (1)	11 (10)	10 (12)
Total	48	45	48	48	130	115	85

FIFA, Fédération Internationale de Football Association; AFC, Asian Football Confederation. Values in parentheses are percentages.

Figure 2 Distribution of age-related grades of fusion of the distal radius of the left hand of U-17 soccer players and a normative population.⁸

cases as V. In contrast, in no cases in the normative population aged 14 years was the fusion of the distal radius graded as IV, V or VI, and in only 5% (6 of 125) of the 15 year olds was it graded as V. In 12 of 27 (44%) 15-year-old U-17 players, fusion of the distal radius was graded as V or VI, whereas this was so for only 5% of the 15-year-old normative population. In the U-17 players, the grade of fusion increased only slightly from the 15 to the 16-year-old players and from the 16 to the 17-year-old players. Furthermore, in contrast with the normative values,⁸ no significant correlation was observed between the age category and the grade of fusion ($p = 0.13$, NS).

DISCUSSION

This study evaluated the age of a representative sample of 189 players of four international U-17 soccer tournaments using MR images of the distal radius and the official documents. Two FIFA and two AFC U-17 tournaments were included in the study because of the different definition of U-17 tournaments of AFC and FIFA. The regulations of AFC clearly indicate that all players have to be younger than 17 years, according to the documents, at the start of the competition, whereas for FIFA U-17 competitions, the players must have been born on 1 January and/or less than 17 years before the year of the tournament—for example, 1 January 1998 and/or later for the competition in August 2005 in Peru. Thus, players in FIFA U-17 World Cups can be 17 at the start of the championship, and this applied to 71% of the players of both FIFA U-17 World Cups included in this study. In contrast, in the AFC championships, 66% of the players included in the study were 16 years old, and 34% were even younger. Therefore the AFC competition is a true U-17 championship, whereas the FIFA tournament is actually an U-18 competition.

The MR images of 27% of the players from the FIFA U-17 tournaments and 15% of players from the AFC tournaments were graded VI (completely fused) which is a substantially higher percentage than in the respective age groups of the normative population.⁸ Comparing the four tournaments, the highest percentage of players with complete fusion of the distal radius (35%) was observed in the FIFA U-17 World Cup 2003 in Finland, and the lowest percentage (6%) in the AFC championship 2006 in Singapore where assessment of MR images was announced before the competition and the players were pre-selected. However, for both types of tournament (AFC and

What is already known on this topic

- To guarantee equal chances for different age groups, age-related tournaments for male and female players have been established in soccer.
- As registration at birth is not compulsory in some countries, other methods of age determination are needed to prevent participation in the incorrect age group.
- Grading of fusion of the distal radius based on MRI assessment is a reliable and valid method for age estimation in 14–19-year-old soccer players.

What this study adds

- MRI investigation of fusion of the left distal radius is a viable tool for screening to estimate the age and degree of maturity of players in U-17 soccer competitions.
- U-17 players seem to be more mature than a normative population of the same age category.
- In contrast with the normative population, no correlation was observed between age category and degree of fusion; this lack of correlation in U-17 players supports the suspicion that the age stated in the official documents of the U-17 players examined might not be correct in all cases.

FIFA), a fall in the rate of complete fusion was observed between the first and the second competition under investigation (FIFA, from 2003 to 2005; AFC, from 2004 to 2006). It can only be hypothesised that this decrease was due to the fact that the team managers were aware that checks were going to be carried out and more careful selection was carried out.

If U-17 players were categorised into age groups according to their official documents, a higher degree of fusion was observed in all groups compared with the age-related values of a normative population of soccer players.⁸ From the MRI results, U-17 players seem to be more mature than a normative population of soccer players. However, in contrast with the normative population, no correlation was observed between age category and grade of fusion. This mismatch between the age stated in the official documents and biological maturity assessed from fusion of the distal radius in some U-17 players cannot be clearly explained, but it supports the suspicion that some U-17 players are older than stated in their official documents. Because of biological variability, the “true” age of an individual can only be estimated with a certain probability, but MRI of the wrist has been shown to be a reliable and valid method for estimating age in 14–19-year-old soccer players.⁸

CONCLUSION

MRI investigation of bony fusion of the left distal radius is a viable tool for screening football players in youth competitions to determine age and degree of maturity, particularly in U-16 and U-17 groups. On the basis of the results of the MRI examination of the left radius, the officially stated ages of U-17 players may not be correct in all cases.

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Figure 1 Ben Kibler.