EDITOR'S CHOICE

Detecting over-age players using wrist MRI: science partnering with sport to ensure fair play

Jiri Dvorak

Detecting the presence of over-age players in age-related tournaments has been a difficult challenge for many sports organisations. "Age-doping" is a form of cheating that involves falsification of information about the age of a player to gain advantage in the sport. This clearly contradicts the ethics of sport and fair play.

Until now, the age of competitors has generally been proven by official documents such as birth certificates. In some regions of the world, however, births are registered at police stations or rural health clinics, or by village elders. Since births do not take place at established hospitals, their registration is often delayed because of cultural, religious and climatic reasons. At times, the large distance between a place of residence and a registration "office" can mean days of travel (and hence delay). Thus, the official "birth certificate" may not reflect the actual date of birth.

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In addition to this phenomenon, there is compelling evidence that some players carry documents that are deliberately falsified. In some competitions, officials' suspicions were raised when an entire team had birthdays in the same month of the year or when numerous players on the team had consecutive serial numbers on their birth certificates. It was also noted that some players appeared to have two sets of travel documents, and officials were bemused when players were shopping for teddy bears for their children in an "under 16" tournament. There was clearly a need to put a stop to this unhealthy practice and bring honour to the sport.

Physical appearances can be deceptive. No scientific tool can accurately match bone age with chronological age. However, skeletal maturation is a reliable variable in evaluating the "tempo" of growth. Evaluation can be based on methods such as development of dentition or the methods described in the Greulich and Pyle Radiological Atlas or by Tanner and Whitehouse. *x* Rays are commonly used for this purpose for medical or legal indications. Wrist *x* rays are readily available and cheap, and emit low radiation. However, the use of *x* ray radiation is illegal in most countries for non-criminal purposes (WHO, IAEA). Member associations of FIFA objected to the use of *x* rays for this purpose in football players.

In the lead-up to November's FIFA U-17 World Cup Nigeria 2009, officials were having familiar discussions. "Are all the players on the competing teams really 17 or under?" Competing teams often raise questions about players who look older than expected. FIFA and all member associations are obliged to provide a level playing field for all players participating at FIFA competitions. Over-aged players clearly have an unfair advantage due to their higher physical maturity as compared with players of correct chronological age.

AGE DETERMINATION USING MRI OF THE WRIST AS AN ALTERNATIVE TO *X* RAYS

In 2003, in response to numerous requests by member associations, FIFA's Medical Assessment and Research Centre (F-MARC) started to investigate the use of biological markers for age determination.

MRI scans of the wrist were performed in more than 500 football players who had confirmed birth certificates. These players of different ethnical origin (Switzerland, Malaysia, Algeria, Argentina, Senegal) were aged between 14 and 19 years. A six-point grading system for the fusion of the growth plate was developed.[1] Based upon the normal population, complete fusion was

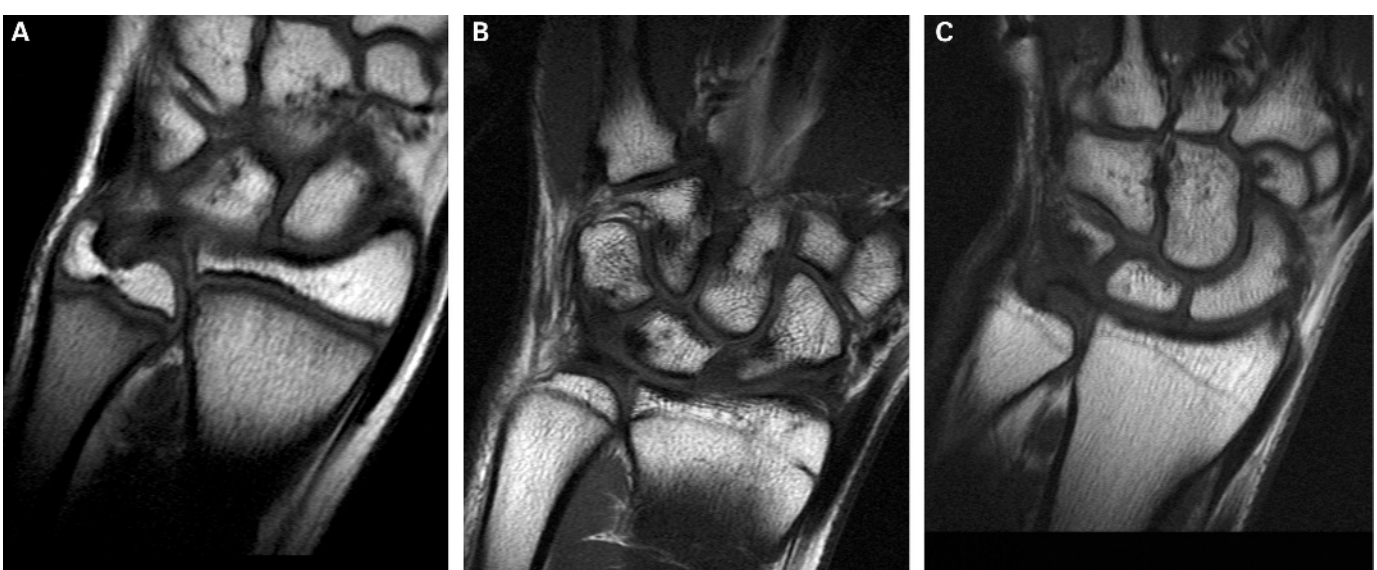

Figure 1 MRI of the wrist of football players: (A) a 15- year-old player with a completely open growth plate; (B) a 16-year-old player with partially fused growth plate; (C) a 19-year-old player with completely fused growth plate.

very unlikely to occur prior to 17 years of age; the probability was below 1%. In other words, if MRI shows complete fusion of a player's wrist, the player is likely to be older than 17 years with a certainty of more than 99%. F-MARC then performed MRI scans of the wrist on players selected randomly at the FIFA U-17 World Cups 2003, 2005 and 2007. The MRI scans of these players showed far higher rates of fusion (up to 35%) than the reference populations[2] (fig 1).

To tackle this potential problem of overage players, FIFA will conduct an MRI of the wrist at the FIFA U-17 World Cup in November. Randomly selected players will be tested in Nigeria under the supervision of FIFA's medical experts. It is noteworthy that following this announcement, some teams who qualified for the competition replaced up to 15 players from the original squad!

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Exercise and bone health: optimising bone structure during growth is key, but all is not in vain during ageing

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The reduction in bone strength and resultant increase in low-trauma fractures associated with ageing represents a prominent and growing societal problem. Although numerous pharmacological agents have been developed to prevent and treat reductions in bone strength as a means to reduce fractures, a commonly advocated intervention is the prescription of load-bearing exercise.[1] The skeleton is mechanosensitive across the lifespan and responds and adapts to its prevailing mechanical environment. This concept is supported by two independent, yet related, articles in this issue of the *BJSM*.[2 3] These papers highlight the potential role of exercise on bone health at two differing stages of the lifespan. Kato *et al*[2] performed a cross-sectional study to show that exercise when young may have lasting effects on bone health during ageing, whereas Martyn-St James and Carroll[3] performed a systematic review and meta-analysis to demonstrate that exercise can have beneficial effects on the postmenopausal skeleton.

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EXERCISE DURING GROWTH MAY HAVE LASTING EFFECTS ON BONE HEALTH

A dichotomy exists between when the skeleton is most responsive to exercise and when it is prone to osteoporotic fracture. Reduced bone strength is predominantly an age-related phenomenon,[4] whereas the ability of the skeleton to respond to mechanical loading is greatest during childhood and decreases with age.[5] In fact, the skeletal benefit of a lifetime of exercise seems to occur mainly during the years of skeletal development.[6 7] This disparate response of the skeleton to mechanical loading with ageing and the reduction in bone strength with age has raised the question of whether exercise-induced bone changes during growth persist into adulthood where they would be most advantageous in reducing fracture risk.

Kato *et al*[2] address this issue in their study of postmenopausal bone health in former adolescent athletes and controls. Weight-bearing exercise when young was found to have persistent effects on bone mass and structure following cessation of exercise, suggesting that exercise during growth may have lasting effects on bone health. Previous studies support the potential short-term sustainability of exercise-induced benefits in bone mass[8–10]; however, these mass benefits do not appear to be maintained into older age where they may be advantageous in reducing the fracture-risk associated with osteoporosis.[11 12] Also, the cross-sectional study design utilised by Kato *et al*[2] introduces some bias due to the potential natural selection of certain individuals towards load-bearing athletic endeavours. Nevertheless, the suggestion of Kato *et al*[2] that exercise-induced effects on bone structure may be maintained is interesting as (1) exercise during growth predominantly influences bone structure rather than mass and (2) mechanisms exist for the long-term maintenance of exercise effects on bone structure.

EXERCISE DURING GROWTH PREDOMINANTLY INFLUENCES BONE STRUCTURE, RATHER THAN MASS, TO ENHANCE BONE STRENGTH

Exercise during growth adds extra material to loaded sites to effectively increase the quantity of bone present. The conventional dogma is to maximise peak bone mass with exercise during the growing years in an effort to offset the loss of bone that occurs during ageing.[13 14] However, mechanical loading associated with weight-bearing exercise generates large increases in bone strength without substantial increases in bone quantity. For instance, it has been demonstrated in animals that very small (<10%) changes in bone mass generated via mechanical loading can result in disproportionate (>60%) increases in skeletal mechanical properties.[15 16] This occurs because the bone formation response to mechanical loading is site-specific and occurs where mechanical demands are greatest. The net result is structural optimisation of the skeleton whereby bone material is distributed in such a way that it is better positioned to resist external loads. This typically involves new bone being laid down as far as possible from the respective axis of bending or rotation, as observed in clinical trials whereby exercise during growth (especially before puberty) caused new bone to be preferentially laid down on the periosteal (outer) surface of loaded bones.[17 18] Such site-specific depositing of