Distal radial fractures in young goalkeepers: a case for an appropriately sized soccer ball

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Abstract

***Objectives*—To assess the rate of wrist fractures in young goalkeepers sustained by the specific mechanism of "saving the ball" and the potential influence of ball size and environmental conditions.**

***Methods*—A prospective, clinic based study in one institution over a 17 month period. Patients were identified by specific questioning. Information on play circumstances and subsequent clinical progress was documented.**

***Results*—Twenty nine fractures of the distal radius were identified in young goalkeepers (age range 6–15 years) as a direct result of saving the ball. Most were managed simply in a plaster cast. Three patients required minor surgical interventions, and all fractures went on to unite without significant complications. Where ball size was known, 12 of the 15 fractures in children aged 11 years or less occurred as the result of impact with an adult sized ball compared with three when a junior ball was involved. This is statistically significant (p = 0.039). In the 10 children aged 12–15 years, only one fracture involved a junior ball; this is also statistically significant (p = 0.027). Six of the injuries (21%) occurred when the ball was kicked by an adult. Injuries occurred in both organised and informal games throughout the year.**

***Conclusions*—This specific mechanism of injury has not been widely acknowledged nor has the potential influence of ball size as a causative factor been examined. Recommendations for an appropriately sized soccer ball for young players exist but are not in universal use. Increased awareness of this particular injury mechanism is required.**

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Soccer is the most popular sport in the world with an estimated 200 million players worldwide. In the United Kingdom, it is the national sport, with 2.25 million players in England and Wales registered with The Football Association, the national governing body, and of these, 750 000 are youth players (Customer Relations Unit, The Football Association, London, UK, personal communication). In addition, there are an unknown, but large, number of children and young adults taking part in informal games throughout the year.

Soccer is classified as a contact sport.[1] This implies that impacts and collisions, such as those that may result in fractures, occur by nature of the sport during the course of games and practice. In the United Kingdom, an estimated 9.8 million new substantive injuries—that is, those necessitating treatment or time off usual activities—occur in adults during sport and exercise every year. Over one quarter of these are sustained playing soccer, which has an injury rate of 19.2 new substantive injuries per 1000 occasions of participation. Overall, fractures account for 1.8% of these new injuries.[2]

In children playing soccer, the most common mechanism of injury producing a fracture of the wrist is a fall on to an outstretched hand. Other mechanisms include contact with other players (be that through fair or foul play) and collisions with equipment such as the goal posts. Goalkeepers, by the nature of their role, may be expected to sustain a relatively higher number of hand and wrist injuries. The impact of the ball against the hands while "making a save" produces a similar mechanism of axial loading and forced extension of the wrist to that occurring in a fall. If sufficient force and energy are involved, fracture of the distal radius may result. This mechanism of injury and the potential influence of the ball have not been readily recognised as a common cause of injury in young goalkeepers.

The Football Association has acknowledged that the needs of children are different from those of adults, introducing its Mini-soccer community programme activity in 1993. In this, they recommend that, for 8–11 year olds, a ball no larger than a size 4 (a "junior" ball) should be used and that a size 3 ball should be used for younger children.[3] Adults and older children generally play with a size 5 ("adult" or "full-sized") ball.

The aim of this study was to document the nature, circumstances, and incidence of fractures to the wrist sustained by young goalkeepers while saving the ball.

Method

Over a 17 month period, from April 1996 to August 1997, all new patients attending the weekly paediatric fracture clinic of a single consultant orthopaedic surgeon had the mechanism of their injury ascertained. Those who had sustained fractures while playing soccer were asked specifically whether the injury had occurred while they were saving the ball. All fractures to the hand and wrist caused by this precise mechanism were recorded. Goalkeepers sustaining a fracture of the distal radius, with or without the ulna, were followed prospectively, their epiphyseal status and clinical progress being recorded. In addition, they completed a questionnaire documenting the conditions and environment at the time of injury. Injuries occurring in outfield players through accidental impact by the ball on the hand or falls while in goal were not included.

Statistical analysis of injuries sustained as the result of impact with different sized balls was performed using a one sample proportion test with a Yates correction factor.

Results

During the study period, about 1920 new patients were seen in the paediatric fracture clinic of the senior author (JBH). These represented less than half of all new patients presenting to the institution, which typically receives patients attending the accident and emergency department on three days during the middle of the week.

In all, 29 fractures of the distal radius, with or without the ulna, in 28 patients were identified as being sustained by goalkeepers with the specific mechanism of saving the ball. One patient sustained a second fracture of the opposite wrist by the same mechanism during the study period. The injuries were sustained by 27 boys (93%) and two girls (7%) with an average age of 10.9 years (range 6–15). Injuries occurred on the right side in 14 patients (48%) and on the left in 15 patients (52%). Injuries were distributed throughout the year, with perhaps a tendency towards the summer months, the traditional out of season period but associated with a greater opportunity for outdoor games.

Figure 1 Lateral (A) and posteroanterior (B) radiographs of the wrist showing a typical fracture pattern in a 10 year old goalkeeper injured while saving the ball.

The fractures were predominantly torus (buckle) fractures of the distal radial metaphysis (fig 1). All patients had open distal radial epiphyses, but only one epiphyseal fracture (a Salter Harris type II) was seen during the study period. We did not see any scaphoid fractures sustained by this mechanism in this group.

Twenty six of the 29 distal radial fractures required simple immobilisation in a plaster of Paris cast for an average period of 3.2 weeks, and no complications occurred. Three fractures required a manipulation under anaesthetic and plaster cast application. In one of these, the position deteriorated while in the cast and required further manipulation under anaesthetic with supplementary k wire stabilisation. No malunions or late growth disturbances were identified.

An adult ball (size 5) was involved in 21 cases (72%), a junior ball (size 4) in four (14%), and the ball was of unknown size in four (14%). Where the ball size was known, 12 children aged ⩽11 years (including all three fractures in 6–7 year olds) sustained their fractures as the result of impact with an adult sized ball and three after impact with a junior sized ball. This difference was significant at the $p = 0.039$ level. In the 10 children in the 12–15 years age group, nine fractures involved an adult ball and one a junior ball. This was significant at $p = 0.027$.

Twenty three (79%) of the injuries occurred when the ball was kicked by a child of a similar age, but in six cases (21%), the ball was kicked by an adult. Adults were involved in five of the 18 injuries in ⩽11 year olds (including two of the three injuries in 6–7 year olds) and one of the 11 injuries in 12–15 year olds.

Ten of the injuries (34%) occurred during organised matches, the remainder (66%) during informal games. Of the injuries occurring in organised games, only one involved a junior football (in a 9 year old), seven involved adult sized balls (four in children aged ⩽11 years and three aged 12–15 years). The ball size was unknown in two cases.

The ambient weather conditions were dry on 26 (90%) occasions and wet on three (10%). Eight fractures (28%) occurred in games played on artificial pitches and 21 fractures (72%) in games on grass. Goalkeeping gloves were being worn on 12 occasions (41%).

Discussion

Properly structured and supervised organised sport for children offers great opportunities for enjoyment and wellbeing. However, with increased participation and intensity of activity, the exposure to injury risk is increased.[4]

True injury rates in young soccer players are uncertain, as inconsistencies in the literature make direct comparisons difficult. Sullivan *et al*[5] found overall injury rates of 0.51 per 1000 playing hours for boys and 1.10 per 1000 playing hours for girls. Injury rates were less in the players under 10 years of age. The upper limb was involved in six of 34 injuries (18%), and

two fractures (5.9%) occurred, one of which was of the distal radius but no mechanism was given. Yde and Nielsen[6] found an overall injury rate of 5.6 injuries per 1000 playing hours. The upper extremity was involved in 4% of injuries and again the injury rate was lower in the younger players. Impacts with the ball accounted for 8% of injuries, but the location and nature of such injuries were not reported.

In Scottish adults, about 4% of all distal radial fractures occur in soccer. In 21%, the mechanism was the ball forcibly striking the hand, but it is not known whether these were goalkeepers saving the ball.[7] However, scaphoid fractures as a consequence of this particular mechanism of injury have been reported.[8]

Much of the interest in ball specific characteristics has been motivated by the potential risk of brain injury through heading, which, like saving the ball, is an integral part of the game. A size 5 (adult) soccer ball, according to Football Association regulations, weighs 410–450 g, has an inflation pressure of 0.6–1.1 atmospheres, and a circumference between 68 and 70 cm.[9] Skilled adult soccer players can strike the ball to speeds of 25 m/s. Balls travelling at velocities of about 18 m/s produce peak impact forces in the region of 900 N generated over a rise time (a measure of ball compliance) of around 3–4 milliseconds.[10] The force of impact from stitched balls was found to be 7% greater than from moulded balls, as their mass is typically greater.[10] Stitched balls have greater compliance than moulded balls.[10] When wet, a stitched ball increases in mass by around 10% with a corresponding increase in impact force.[11] Increasing inflation pressures also raises impact forces by shortening the rise time and hence the time available to absorb energy.[11]

Children's bones are more ductile than adults—that is, they have a greater range of plastic deformation before fracture occurs. Torus fractures of the distal radius result from a combined axial and shearing force to the bone, which then fails in compression on the dorsal metaphyseal cortex, an area where there is relatively more cancellous bone. We are not aware of any studies that have shown the forces required to fracture a child's radius. Weiss and Sponseller[12], however, have reported that forces of 55–90% body weight are sufficient to cause distal radial epiphyseal fractures in adolescent weightlifters. Given that an average 10 year old child weighs about 30 kg, it would appear that the forces involved in ball impacts are well within the range necessary to cause a fracture.

The influence of ball size, and hence mass and energy, would seem important, particularly for goalkeepers who deliberately and repeatedly take impacts from the ball on their hands. Alternatively sized balls for younger players are readily available. Size 4 balls have a circumference of 63.5–66.0 cm and weigh between 350 and 390 g. Size 3 balls have a circumference of 59.5–62.0 cm and weigh 320–350 g (Mitre International Limited, Cheadle, UK, personal communication).

The fractures sustained in this study appeared quite typical of the spectrum of distal radial fractures seen in children. Most were managed simply, with only three fractures requiring any surgical intervention, and all healed without major incident. Nevertheless, it was surprising to see these fractures, as a consequence of a very specific mechanism of injury, appearing so regularly in our clinic when such has not been previously highlighted.

Our results suggest that children who sustain a wrist fracture by this mechanism are more likely to do so when playing with an adult sized ball than a junior one. It would appear therefore that precautions are warranted when children are playing soccer with equipment that does not match their size. In addition, education of coaches, parents, and players to raise awareness of the potential of injury by saving the ball is recommended. The teaching of correct goalkeeping technique, such as adopting a "safe" position when making a save, would also seem important. Sports governing bodies play a particular role in this respect by setting standards and coaching and refereeing qualifications.

Although injuries will continue to occur in both organised and spontaneous games, the matching of players for size and skill level and the use of appropriately sized equipment, in particular the ball, should minimise any inherent risks of the sport for young children.

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Take home message

Children are susceptible to bony injury with relatively low forces such as those occurring in sport. The wrists of young goalkeepers appear to be at risk while saving the ball. Matching for size and skill level and the use of appropriately sized equipment, in particular the ball, are recommended.