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Review

# Injuries and Pain Associated with Goalkeeping in Football—Review of the Literature

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**Featured Application:** Physiotherapy in football, designing programs for injury prevention, goal-keeping coaching.

**Abstract:** Knowledge and research about football goalkeeper (GK) injuries are scarce, which prevents the development of evidence-based injury prevention programs. Fortunately, progress is evident in injury prevention strategies in outfield football players. However, a GK fulfills a unique role, and an injured GK can substantially impact a team. Thus, there is a need to clarify and summarize current knowledge concerning football goalkeeper pain and injuries. This narrative review aims to present the best-evidence synthesis of knowledge about football GK injuries and pain, their type, location, and incidence. A secondary aim is to contrast these findings with outfield players and identify knowledge gaps. Scientific databases were searched for the following indexed terms: goalkeeper, injury, soccer, and football. Original papers, including case studies and systematic reviews published from August 1994 to March 2021, were screened for relevance using a priori criteria and reviewed. Commonly described injuries are fractures, luxation and dislocations in the fingers, hand and wrist. The quadriceps femoris and forearms muscles are the most frequently described muscle and tendon injuries. Further, football GK injuries differ in type, location, and incidence compared to outfield players. Whether GKs suffer fewer injuries than players in other positions, whether GK suffer more injuries in training than matches, and whether they sustain more upper limb injuries comparing to field players is still unclear and controversial. Few studies assess pain, and current data point to the development of hip and groin, thigh, knee, arm and forearm pain resulting from training and match play. Due to the crucial role of GK in the football team, it is recommended to use the injury burden as a parameter considering the number and time-loss of injuries in future studies.

**Keywords:** goalkeeper; injury; pain; soreness; football; soccer; muscle; tendon; fracture; luxation



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## 1. Introduction

Football is a popular sport with the highest risks for injury [1,2] and has the most significant number of injured players yearly. However, injury and pain assessments in football goalkeepers (GKs) are scarce relative to their essential role. Indeed, a football GK is vital, and the game mechanics differ entirely from outfield positions. Undoubtedly, GKs' playing and training conditions can put them at a high risk of injury as well. Thus, a comprehensive understanding of sustained injuries and pain reports in football GKs would be valuable for medics, physiotherapists and coaches.

Since the 1990s, the GK's position has evolved dynamically. Although shot stopping will always be an essential skill, newer demands imposed on modern GKs, such as ase-curation of the defensive line, making clearances and active foot play, bring additional

injury risks. GKs fulfill unique and crucial defensive and offensive roles. As a result, GKs often possess different abilities and attributes than outfield players. For example, GKs demonstrate better high jump performance but perform worse on speed and VO<sub>2</sub> max tests than outfield players. Thus, it would be reasonable to expect that the rate and type of injuries may also differ.

Such differences are in part due to the selection process. In professional football, criteria for GKs and field players are different and include biological age, maturity, body height, predicted height, handgrip strength and jump performance [3]. This may explain why GKs tend to be statistically higher, heavier and have more % of body fat than any other player or age group [4].

Nowadays, most publications concerning sustained injury and pain in GKs consist of case studies, a small sample size, or provide data using different methodology and definitions which impede direct comparison. Thus, insufficient and varied studies preempt a systematic review.

### *1.1. Characteristics of Football Goalkeepers Play and Risk of Injury*

#### 1.1.1. Offensive Scenarios

Depending on the game, GKs' actions are between 60–80% offensive play [5–9]. A modern-day GK often uses their feet to play the ball to gain an advantage for his team or initiate counterattacks. GKs often make passes at the distances of 50 m or more in contrast to outfield players who more often pass at shorter distances [8]. GKs initiate offensive play by goal kicking, which is played only with the feet due to the rules. Offensive in action play constitutes 60% throwing and 40% passing with the feet in training game conditions [10]. Furthermore, effective GKs combine various abilities and characteristics, including explosive force, speed, and coordination with their high body height [3,4,7,8].

#### 1.1.2. Defensive Scenarios

An essential skill of a GK's defensive gameplay is shot stopping. On average, GKs of the highest level perform about 23 different defensive actions per match [5]. For these games, there is a varying frequency of cross interceptions, one-to-one duels, and clear-outs [5,7,11]. There is approximately  $6.2 \pm 2.7$  dives,  $3.8 \pm 2.3$  jumps and  $18.7 \pm 6$  very dynamic displacements (forward, sideways, and backward) per game [5]. Results from other studies confirm these findings (on average:  $10 \pm 1$  dives,  $15 \pm 5$  jumps,  $8 \pm 3$  high speed changes of direction and  $16 \pm 3$  explosive efforts) and add similar data characterizing goalkeeping training (on average  $51 \pm 11$  dives,  $43 \pm 15$ ,  $34 \pm 12$  high speed changes of direction and  $70 \pm 18$  explosive efforts) [12].

#### 1.1.3. Distance Covered during a Match

GKs cover far shorter distance during gameplay than outfield players [8,10]. During 90 min gameplay, on average, elite outfield players cover a distance of 10 to 12 km [13–20]. This distance includes sprinting (approximately every 90 s), walking and long-distance running (about 60 m) [21]. In contrast, GKs cover shorter distances, ranging from 3.5 to 6.5 km during a match, with an average of 5.5 km. The majority of this distance is walking [7].

#### 1.1.4. Risky Conditions and Situations

According to many authors [22–25] GKs get into a number of situations during training and matches which pose a high risk of injury. For GKs there are additional specific situations which can cause injury risks that are not present in the actions of field players. Such actions are crosses interceptions, 1v1 duels and shot stopping with diving techniques.

Non-contact injuries are caused by dynamic movements, including quick changes of direction, sprints, dives, jumps, throws, and kicks. Jumps and shot stopping, as well as diving saves, require large and rapid generation of forces at push-off [11,26–28] and include many diving techniques, which mostly end in hitting the ground [12]. Therefore,

it is reasonable to anticipate that shot stopping training can lead to contusions, bruises, abrasions, wounds and even fractures [29]. Moreover, repetitive impact of diving saves may result in elbow and other upper extremity injuries. Additionally, some diving saves require the body to contort into extreme ranges of motion. The goal of deflecting the ball may cause muscle strain, tendon rupture, or joint sprains [25]. Shot stopping by catching is considered ideal as the opponent's attack ends and a possibility of rebound or second shot is reduced. However, catching powerful shots or deflecting the ball is not without risk. Such catches can cause sprains, dislocations and fractures of wrists, hands or fingers [30–32]. During throwing, an excessive range of motion combined with a high level of dynamics can lead to injuries, especially in the dominant arm [33,34].

Contact (with an opponent or a teammate) injuries are caused by colliding with other players, being hit by the ball, falling on the ground and, in exceptional cases, even hitting a goal post. Passing under pressure or sweeping before a rival reaches the ball puts GKs at the risk of being kicked, hit or rammed by the opponent. Such situations can lead to bruises, abrasions, wounds, muscle strains, joint sprains and fractures. Similarly, aerial play and cross interceptions involve a high risk of colliding with another player [35]. At the same time, landing from aerial play can lead to joint sprains, muscle and tendon strains or ruptures. Additionally, 1 × 1 defensive situations often start dynamically and end in diving under opponents' feet, blocking the ball, or reaction saves.

A risk of trauma in the lower limbs is connected with running, kicking the ball, jumping, accelerating, decelerating, and changing directions both in GKs and in field players. In addition, kicking a ball and contact with other players challenging for a ball or making a tackle can result in trauma. Long passes demand dynamic movement with a lot of force production, leading to muscle and tendon strains, muscle attachments, avulsions (avulsion fractures) [36,37], or sprains—especially ankle sprains [2].

The factors described above, i.e., quick movements, excessive range of motion and impacts are apparent sources of pain and may cause injuries.

### 1.2. Pain and Injury Definitions

Due to the fact that the topic of football GK injuries rarely shows up in the scientific literature and that analyzed papers arose over a long period of time, the studies differ in injury and pain definitions, as well as in methods of quantifying the occurrence of an injury. There are different parameters used—i.e., injury incidence, injury risk or the injury hazard ratio. The differences cause difficulties in comparison and interpretation of the results. It is recommended to use definitions of injury and methods described in the "Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries" by Fuller et al. [38]. This document defines injury as any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time-loss from football activities. An injury resulting in medical attention is considered a "medical-attention" injury, and an injury resulting in a player being unable to fully participate in subsequent football training or match play a "time-loss" injury. This definition also includes absence due to illness, disease and mental complaints.

Bahr (2009) claims that, depending on an injury definition, the injury incidence can be very low (time-loss or medical attention definitions), despite high prevalence of pain from pain indicating surveys [39]. A widely used time-loss injury definition overlooks scenarios where an injury may lead to a time-loss injury in one athlete but not in another, which makes pain monitoring even more significant.

The International Association for the Study of Pain (IASP) defines pain as "An unpleasant sensory and emotional experience associated with or resembling that associated with, actual or potential tissue damage" [40]. However, Kumar and Elavarasi suggest that pain should be considered as "the subjective interpretation of the discomfort" [41], which emphasizes the subjectiveness of the phenomenon.

## 2. Aim

This narrative review aimed to provide a best-evidence synthesis about football GK injuries and pain, in particular, their type, location, incidence, and risks which may occur during game and training conditions. A secondary aim was to contrast these findings, where appropriate, with outfield players and identify knowledge gaps.

## 3. Materials and Methods

Pubmed, Web of Science and Google Scholar databases were searched for indexed terms, including the following key words: goalkeeper, injury, soccer, and football. Other sources of data were references of analyzed papers. Only English-written studies on football/soccer goalkeepers, citing injury type, location, incidence, and or risk, were screened for inclusion. Over two hundred original papers, including case studies published from August 1994 to March 2021, were screened for relevance using a priori criteria. Due to the fact that the focus of this article is on injuries and pain, articles on treatment, post-surgery complications, post surgery pain, and rehabilitation were excluded. The methods aimed to provide best-evidence synthesis useful especially for researchers working on preventive programs or particular injuries, medicians, physioterapeuts and coaches.

After excluding articles that did not match the criteria in the search and selection process, the authors included 25 case studies in the review. A summary (Table 1) of 10 articles that compare incidence of injuries in different positions in football, including goalkeepers, was prepared and another table comparing injury location in GK of 6 studies was provided. To describe the presented topic the authors analyzed and quoted additional 51 other original papers, including systematic reviews. Overall, 92 articles have been quoted in this narrative review.

## 4. Discussion

### 4.1. Outfield Players' Injuries vs. Goalkeepers' Injuries

On average, an elite football player suffers from 1.5 to 7.6 injuries per 1000 training hours and 12 to 35 injuries per 1000 h of a match [23]. Kirkendall and Dvorak reported that the most common injury location in all positions was the lower limb (67.7%), followed by the upper limb (13.4%) [42].

**Table 1.** Injuries in GKs and field players.

Study	Match/Training	Main Findings
Andersen et al. (2003) [43]	Match	Less injuries in GK
Aoki et al. (2012) [44]	Match	Less injuries in GK
Arliani et al. (2011) [45]	Match	Less injuries in GK
Kristenson et al. (2013) [46]	Match and training	Less injuries in GK
Deehan et al. (2007) [47]	Match and training	Less injuries in GK
Carling et al. (2009) [48]	Match	Less injuries in GK
Martín-San Agustín et al. (2021) [49]	Match and training Female football	Less injuries comparing to FW and MDF, more injuries comparing to DF
Dauty&Collon (2011) [50]	Match and training	No differecne according to player position
Morgan and Oberlander (2001) [51]	Match and training	No differecne according to player position
Timpka et al. (2008) [52]	Match	No differecne according to player position

GK—goalkeepers, FW—forwards, MDF—midfielders, DF—defenders.

Many studies show that GKs suffer fewer injuries than field players. There are also studies indicating that GKs do not differ in injury incidence from field players (Table 1).

GKs suffer more injuries during training than matches due to much more explosive actions and goalkeeper-to-player interactions comparing to matches [9,12,25]. This stands in contrast to field players who suffer more injuries during matches than training [2,46] and is typical for many other sports [2]. However, different studies present contrasting results, i.e., in the study of Kristenson, GKs' injury incidence was higher in competition than in training (12.1 vs. 3.5, respectively) [46], which is proven also in female football GKs by the study of Martín-San Agustín et al. with the results of IR 14.04 in matches vs. 2.57 in training [49]. Strand et al. published a study of Norwegian elite GKs showing that GK injury incidence was 27.9 per 1000 playing hours of matches, 23.6 for specific GK training and 9.1 for other types of exercise [35].

GKs cover shorter distance during play and training [7,9] and use the upper limbs more frequently to execute defensive and offensive actions comparing to field players. When it comes to the distribution of injuries location, there are controversies in the literature. Some authors claim that GKs have higher upper limbs than lower limbs injuries incidence [23,46,53], especially of fingers, hands and wrists [53] but results of other studies do not agree with this statement. (Table 2). In the study of Strand et al. injuries of the upper limbs represented 36% of all injuries in GKs [35]. Hart et al. and Ekstrand et al. reported a greater risk of shoulder injuries in GKs than in outfield players [54,55]. The most injured area of the shoulder is the rotator cuff, causing partial or total tear.

**Table 2.** Injuries location—results by different studies.

Study	Par.	Total	Head, Neck	Trunk	Upper Limbs	Lower Limbs
Aoki et al. (2012) [44]	IRR	-	4.06	1.30	1.63	5.93
Kristenson et al. (2013) [46]	II	4.6	0.2	0.7	1.0	2.7
Ekstrand et al. (2013) [55]	II				0.8	
Goodman et al. (2018) [25]	II				0.83 (shoulder and elbow)	
Hwang-Bo and Joo (2019) [56]	%			12% (head and trunk)	31%	57%
Błażkiewicz et al. (2018) [57]	%			9.6% (head and trunk)	34.6%	55.8%

IRR—Injury Risk Ratio. II—Injury Incidence.

A report by Kristenson et al. about injuries in all football players positions with an emphasis on newcomers to professional football showed higher injury hazard rates (HR) for field players (defenders = 1.91, midfielders = 1.78, forwards = 1.82) compared to GKs (HR = 1.0) as defined by time-loss injuries. Most injuries occurred with no contact (HR = 3.2) compared to those resulting from contact (HR = 0.9) with another player or with an object (HR = 0.3). Most GK injuries concerned muscle and tendon (injury incidence—II = 1.8) followed by joint/ligament (II = 1.2). The most common locations were the lower limbs (II = 2.7) compared to the upper limbs, trunk and head/neck (1.0; 0.7; 0.2 respectively). GKs had higher II of the upper limbs and trunk and higher II caused by contact with an object (ball, goalpost) compared to field players. Overall, (all playing positions), injury HR increased with age and peaked for experienced players 29–30 years old. The experienced players had significantly higher injury incidence (II) than newcomers for muscle and tendon injuries (3.6 vs. 1.6 respectively) and for the lower limbs (6.8 vs. 4.4 respectively). Generally, newcomers (to a high level football) had lower injury hazard rates (HR) than

established players (0.77 vs. 1.0 respectively), but they had a higher risk of fractures. In the discussion section the authors underlined the need of creating different prevention strategies for GKs [46].

#### 4.2. Pain in Outfield Players

The most frequent location of pain complaints in outfield players is the hip and groin region, which comprises approximately 70% of football players during the full-time season [58,59]. The authors cited above observed recurring pain in the hip and groin region and a significant correlation with decreased function and quality of life. Furthermore, groin pain represents a serious problem due to high frequency of long-term symptoms and a high risk of pain recurrence [59]. Hölmich et al. reported a high impact of adductor muscle and iliopsoas muscle pain on future injuries in the hip joint and groin area [60].

#### 4.3. Pain in Goalkeepers

The author's own research shows that during a training camp football GKs suffer different types of pain (muscle pain, joint pain, pain caused by impact), in which muscle pain is the most frequent and covers the biggest body area (Table 3) Every GK examined in the study indicated impact caused pain (100%,  $n = 24$ ), 96% (23 of 24) stated muscle pain and 67% (16 of 24) indicated joint pain not caused by impact [61].

**Table 3.** Different types of pain in football goalkeepers ( $n = 24$ ) following training during preseason training camp (based on Muracki et al., 2019 [61]).

Type of Pain	Most Frequent Localization	$n$ out of 24	% of all
Impact caused pain	Hip and groin	16	67%
	Forearm and arm	16	67%
Muscle pain	Thighs	21	88%
Joint pain	Hip and groin	7	29%

Typically, a professional GK participates in football activity 5 to 10 times a week (including team trainings, goalkeeping sessions and all other types of football training) and plays 1–2 matches weekly during the starting season [12]. Under these conditions, pain can be always present. Pain can vary in type and localization, but if it gains a status of the same type in the same localization, it may be an alarm signal for a player and medical staff. Pain often accompanies recurring micro-traumas [44] making regular pain monitoring necessary for injury prevention.

#### 4.4. Goalkeepers' Injuries of Upper Limbs

The analysis of the literature points to the conclusion that treatment of the upper limb injuries in GKs is generally successful. Conservative treatment is mainly used, the time-loss period is short (2–12 weeks) and coming back to the same sport level is very likely. Time-loss, however, is typically greater in GKs compared with players in other positions [53]. Of all upper limbs injuries only shoulder traumas are more severe and lead to even longer time-loss injuries, which makes the shoulder injury burden more significant [23,54].

##### 4.4.1. Fingers, Hand and Wrist

Frequent hand contact with the ball is the reason why football GK is prone to injuries of hands [62]. GKs had a 7-fold higher incidence of the forearm, hand and wrist injuries and an over 1-week longer mean layoff time compared with outfield players. Most of these injuries were fractures [53]. The results presented by Muracki et al. showed that during a training camp 21% of GKs (5 of 24) indicated pain caused by impact in fingers, hand and wrist and 17% of GKs (4 of 24) indicated joint pain in these areas [61] (Table 3). The main cause of finger injuries is contact with the ball during unfortunate catching. This leads to fractures, tendon ruptures, mallet fingers and finger sprains. The hand, wrist and forearm and their joints are functional elements which are endangered by frequent

contact with strong shots which lead to overextension mechanism. These types of repeated microtrauma may cause unidentified pain or stress fractures in the wrist bones. The impact of the ball against the hands while trying to catch or deflect produces a similar mechanism of axial loading and forced extension of the wrist to the one which occurs during a fall when a person tries to support himself with the hand. The size and weight of the ball as well as force used to shoot play a crucial role in the injury hazard ratio in children football. According to Boyd, Brownson and Hunter the hazard ratio is increased when adult size ball is used, an adult shoots and is highly increased when there is a combination of these conditions. The main finding of their study was that 80% of fractures in children aged 11 or under were caused by impact of adult size ball. In children aged 12–15, only one fracture resulted from a junior size ball and 21% of the fractures were caused by an adult kicking the ball. Goalkeeper gloves were used in 41% cases. The authors recommend using the appropriate ball size to the age of practicing GKs and players and having increased awareness of this particular injury risk [29].

Another typical hazardous situation is punching—when a GK tries to hit a ball the wrist should be straightened. Even slight extension or flexion can lead to exceeding the range of motion, which may result in sprain or fracture of the wrist or forearm bones. Yamamoto et al. (2019) underline that trapezoid fractures can be easily overlooked during an initial hospital visit. The authors claim that if there is pain in the wrist and hand after punching a ball the presence the wrist fracture should be examined [31]. The symptoms can be discrete or ambiguous, which makes diagnosis difficult. If diagnosis and treatment is implemented quickly, a prognosis is good. However, due to poor blood supply to the wrist bones, old fractures can make conservative treatment difficult and surgical treatment may be necessary.

Long term consequences of GK playing and training for the wrist, hand, and fingers were analyzed by Hilber et al. Their study shows that, after 20 years of playing recreational football, GKs had more restricted finger movements, experienced more pain and swelling, as well as higher levels of instability in the wrist and finger joints comparing to outfield players [32].

The extraordinary injury mechanism occurring in GKs is connected with the construction of football goals. The hooks used to mount the net on the goal constructions can cause traumatic finger injuries which happen when a GK with a ring on the finger jumps to put the net over hooks—catch on the ring can lead even to the finger amputation [62]. Contemporary goals have plastic hooks situated parallel to the goal crossbar, which eliminates this type of risk, but older goals should be avoided and replaced.

#### 4.4.2. Forearms, Arms and Elbows

GKs often make dives to stop a ball shoot to the corners of the goal, which leads to landing on the ground on the side of the body. These, as well as other, types of interventions and being hit by the ball, contact with the opponent, trampling, contact with a goal construction or accidental falls may evoke a risk of trauma and the forearm, arm and elbow injuries. The results of Muracki et al. shows that 67% of GKs (16 of 24) indicated pain caused by impact in the area of forearms and shoulders. Joint pain in the elbow region was signaled by 17% of GKs (4 of 24) and 33% (8 of 24) indicated muscle pain in the upper limb [61]. Kraus et al., in their report, claim that fractures of the distal radius are the most frequent fractures of long bones during childhood and adolescence, thus the mechanisms of the fracture are differential. The authors analyzed 516 distal radius fractures suffered by children and adolescents, which had different causes. Most of the football radius fractures—48 (78.7%)—occurred due to falling. The authors focused on football GK injuries and found 13 cases in which the trauma was caused by a sharp shot ball. Patients were reexamined after 10 months and all of them returned to the same sport level [30].



#### 4.4.3. Shoulders

A number of shoulder injuries is an increasing problem in football, whereas GKs are even more exposed to shoulder disorders than other field players [23,25]. Reports from European biggest football tournaments, perceptions and procedures of physicians of football best European representations and studies analyzing electromyographic muscles activity were analyzed to design the upper limbs injury prevention program in football GKs, which was named Fifa11+ Shoulder (Fifa 11+ S) [23].

GKs' actions include different dynamic movements of shoulders, such as throwing a ball, diving and deflecting a ball with one or two hands, catching and punching a ball which can lead to muscle and tendon injuries. Repeated interventions ending in landing on the side of the body on the ground also evoke injury risk in the shoulder area. The research of Strand, Krosshaug and Andersen showed that the most common overuse injuries are located in the shoulder area [35]. The analysis of shoulder and elbow injuries in GKs versus field players in NCAA from season 2009–2010 to 2013–2014 shows that GKs suffer more elbow and shoulder injuries compared to field players—8.3 vs. 1.8 incidents respectively per 10,000 athletic exposures (AE). GKs face even more risk of elbow and shoulder injuries during practice (21.3-fold) and during preseason (16.1-fold) than field players. Female GKs have 7.7-fold higher injury incidents in this location than female field players and 1.9-fold higher than male GKs. The most frequent injuries were acromioclavicular joint injuries, rotator cuff tears/sprains and elbow and shoulder instability [25]. The literature provides evidence that muscles of the shoulder girdle can suffer tear during GKs' dynamic actions, such as ball throwing, punching, or diving. A case study of a football GK with musculotendinous rupture of the distal biceps brachii describes the mechanism of the trauma occurred during an overhead ball throw with a single arm [33]. The case study published by Maciel describes a case of a GK with the teres major tendon rupture [34]. The case study of Fysnetzou presents an injury of latissimus dorsi tear during match play [63]. Though the type of injury is rare, the mechanism is frequent in GKs play and training. Study analyzing GK actions during gameplay in different training games conditions showed that the ball was played with hands by the GK in 58,9% of offensive actions [10]. GKs' diving causes hazardous falling on the forearm, which can lead to the shoulder dislocation [23,25,54]. This type of injury can bring wide complications because of numerous muscles and tendons surrounding the shoulder area, as well as the joint complex structure. Complete return to sport can be extended to a year when complications occur [64].

#### 4.5. Goalkeeper Injuries of Head, Neck, Chest, Trunk and Back

There is a gap in scientific literature concerning GK injuries in the area of head (excluding dental trauma), neck, chest, trunk, and back. Injuries of shoulder girdle muscles were presented in the part of this review describing shoulder injuries in this review because they are functionally much more connected with the shoulder, though they are situated in the back.

The literature on head injuries in football concerns mainly heading the ball, which is atypical for GKs. During search process we found one study concerning heading in GK. It reported that GKs made three head hits during the whole season [65] which is far to less to bring any conclusions. The study of Muracki et al. (2019) analyzing pain in GKs showed that only 4% of GKs (1 of 24) indicated impact pain in the head and neck area, 38% (9 of 24) reported chest, trunk, and back impact pain. Muscle pain was indicated by 33% in the chest area (8 of 24), 29% (7 of 24) in the area of the neck and shoulders and 21% (5 of 24) in the area of the abdomen and also 21% (5 of 24) in the back. Joint pain was indicated by one GK in the neck area [61]. The study of Tunãs et al. (2015) shows that 70% of female GKs reported low back pain [66]. Female GKs are more prone to suffer concussion comparing to male GKs [67].

Football GKs are more endangered to maxillofacial and dental trauma than field players. Some authors recommend that GKs use helmets during the game due to the life-threatening consequences of this type of injury [68–70].

#### 4.6. Goalkeepers' Injuries of Lower Limbs

##### 4.6.1. Hips and Groins Regions

The groin and hip area seems to be very often affected by pain and injuries in football GKs, which is the reason why GKs should use protective shorts. In the study of Muracki et al., analyzing pain in GK during a training camp GKs often suffered pain in the lower limbs, groin and hip caused by impact. The area of groin and hip was indicated the most frequently. In terms of muscle pain, GKs frequently reported the thigh, calf and gluteus area and thigh area was the most frequent (88%, 21 of 24 GKs). Joint pain was indicated in the area of groin and hip, knees, and ankles (29%, 27%, and 21%, respectively) [61].

Muscle injuries (rupture, tear, strain, cramps) are the main injury type in the groin and hip area in football players (all positions) and represent 60% of all injuries in the study of Lundgårdh, Svensson, and Alicsson. Unspecific overuse symptoms, tendon injury, contusion, haematoma, synovitis and other types of injury represent 24%, 6%, 4%, 1%, 1%, and 5%, respectively, of all injuries reported. GKs suffered 6% of the analyzed hip and groin injuries [71]. In contrast the study of Schmitt et al., which focused on hip and groin injuries, showed that in football GKs of different age, gender and sports level, contusions and abrasions occur the most often. Abrasions were reported by 80–100% of players and contusions were indicated by 48–71% depending on a group. Other types of injuries were less frequently reported—synovitis of hip joint by 7–20%, arthrosis of hip joint only by 3% and fractures only by 2% of male amateurs. Bursitis was more often reported by professional than amateur players, but generally amateur players have a higher injury rate than professional ones. The injury risk was higher during training exercises than during a match. It is assumed that the reason is a higher number of interventions and goalkeeper-to-player interactions during training exercises than during the same time amount of match play. The authors state that in their study there was no influence of age, gender and exercise intensity on the injury rate. The injury rate was higher when playing and training on artificial grass compared to natural grass, but the difference was not statistically significant. The use of protective goalkeeper shorts did not influence the injury rate [72].

The further analysis of the issue of protective shorts conducted by Schmitt et al. showed that the best models can reduce impact forces on the hip up to 53%, force acting on the neck of the femur bone by over 63% and vertical force also by 63%. The authors claim that padded shorts did not influence the observed injury rate but add that it was not measured whether the use of padded shorts changed the injuries severity level [73]. Despite the fact that goalkeeper padded shorts may not provide perfect protection, it may lower the severity of skin abrasions and bruises. Coaches and professionals should consider that repetitive micro trauma caused by overtraining or overuse can cause deformity of the femoral cam and neck in exceptional cases [74].

The anterior inferior iliac spine (AIIS), which is the attachment site of the straight head of the quadriceps muscle of the thigh, is a point with high injury risk. Injuries of proximal rectus femoris avulsion, avulsion fracture, tendon tear and ossification of tendon are presented in the scientific literature [36,37]. Dunsmuir and colleagues described a case study of injury of the anterior superior iliac spine (ASIS) which provides attachment for the inguinal ligament, and the sartorius muscle [22]. A typical injury mechanism occurs when kicking a ball hard during training or match play. Despite the fact the rectus femoris muscle is one of the biggest muscles in the whole human body, the GKs managed to continue play after suffering the injury in the described case study. A proper diagnosis is difficult because the symptoms are unclear and may be present only during kicking or sprinting. That is the reason why GKs may continue not only match play but also the season without thorough examination and treatment and suffer multiple re-injuries. Esser et al. discuss whether

the surgical operation or conservative treatment is preferable in similar cases, but they recommend early ultrasound or MRI examination to make a proper and differentiating diagnosis [37]. Resnick et al. claim that this type of injuries may be caused by a single forceful contraction or by numerous chronic insults. The trauma may involve ischial tuberosity, anterior inferior iliac spine and anterior superior iliac spine. Adolescents who kick with great force are the most susceptible to these injuries. The authors recommend biopsy to differentiate between avulsion fractures and ossification processes and possible malignancy [36]. Failure to diagnose and treat such injuries complicated by infection could lead to chronic osteomyelitis, bone destruction, or septicemia [22].

#### 4.6.2. Knees and Calves

Knee injuries are common in football. In the study of Błażkiewicz et al., 27% of GKs reported knee injuries [57]. However, according to Schiffner et al., GKs are significantly less prone to suffer an ACLR injury than outfield players [75]. During a training camp dedicated to GKs 58% of GKs (14 of 24) indicated pain caused by impact in the knee area and 21% (5 of 24) in calves and feet. Muscle pain was reported in 38% of participants (9 of 24) in the calf areas. Joint pain in the knee areas was indicated by 21% of GKs (5 of 24) [61]. Fractures of tibia and fibula are the most common in youth football players over 13 years of age and are hallmarked by delayed return to sport and complications [76]. Though these fractures are common in football, GKs are less prone to fractures of the lower leg. These fractures typically occur due to contact during slide tackles, a collision of two players, and a standing player's kick. The typical return time is about 40 weeks. The general conclusion is that the lower leg fractures are severe and it is discussed whether shin guards provide satisfactory, if any, protection [77,78].

#### 4.6.3. Feet and Ankles

Despite the fact that ankle injuries are common in football [2], the scientific literature lacks articles describing this type of injury in GKs. The results of the study of Muracki et al. showed that 21% (5 of 24) of GKs felt pain in the area of feet and calves as a result of an impact and 17% (4 of 24) of GKs indicated pain in the ankle joint [61]. In the study of Błażkiewicz et al., 12% of GKs reported injury in the foot and ankle areas [57].

Luthje and Nurmi published a case study of a male football GK who suffered an injury of the mid-tarsal region of the foot during a training game. The injury mechanism was excessive abduction–plantar–flexion. The diagnosis was made by means of radiograph, which showed fracture–dislocation of the tarsal navicular. The patient underwent a surgical operation of closed reduction with percutaneous fixation using two Kirschner wires. The pain in the mid-foot prevented the patient from returning to play [79].

#### 4.7. Summary of the Case Studies

In most of the cases described in the literature goalkeepers were able to go back to sport to the same level of competition (Table 4). The authors underline the importance of a proper and careful diagnosis, implementation of adequate treatment as soon as possible, as well as proper rehabilitation.

**Table 4.** Summary of the case studies outlining goalkeeper injuries.

Study	<i>n</i> of Cases	Injured Structure	Name of the Injury	Localization	Situation	Average Time Loss
Scerri and Ratcliffe (1994) [62]	3	Finger	Eing finger avulsion	fingers	Equipment preparation	Unknown/not reported
Charalambous, Rajkumar and Samarji (2002) [80]	1	Joints	Double dislocation of the proximal and distal interphalangeal joints of the little finger	fingers	Shot stopping	3 weeks
Shyamsundar and Macsween (2005) [81]	1	Joints	Simultaneous dislocation of the proximal and distal interphalangeal joints of the ring and middle finger	fingers	1v1	8 weeks
Tomcovcik, Kubasovský and Kitka (2003) [82]	1	Joints	Simultaneous double interphalangeal dislocation in the little finger	fingers	1v1	1 week
Degreeef and De Smet (2009) [83]	1	Tendons	Multiple simultaneous mallet fingers	fingers	Shot stopping	7 weeks
Giannini et al. (2004) [84]	1	Bones	Phalanx fracture	fingers	Not reported	8 weeks
Mills, Charalambous and Hayton, 2009 [85]	1	Tendons	Bilateral rupture of the extensor pollicis	hand	Not reported	0
Perugia, Ciurluini and Ferretti (2009) [86]	1	Tendon	Extensor pollicis longus tendon rupture	hand	Not reported	16 weeks
Green and Rayan (1997) [87]	2	Bones	Scaphoid fracture	wrist	Shot stopping	No full treatment
Pidemunt et al. (2012) [88]	1	Bones	Bilateral stress fracture of the carpal scaphoid	wrist	Shot stopping	24 weeks
Saglam et al. (2014) [89]	1	Bones	Bilateral scaphoid stress fracture	wrist	Not identified	12 weeks
Yammamoto et al. (2019) [31]	1	Bones	Trapezoid Fracture Associated with Scaphoid Fracture	wrist	Cross interception	20 weeks
Boyd, Brownson and Hunter (2001) [29]	29	Bone	Distal radius fracture	forearm	Shot stopping and diving save	3.2 weeks
Kraus et al. (2007) [30]	13	Bone	Distal radius fracture	forearm	Not reported	3–8 weeks
Lopez-Zabala and Fernandez-Garcia (2013) [33]	1	Tendon	Distal biceps brachii musculotendinous ruptures	arm	Ball throwing	52 weeks

Table 4. Cont.

Study	n of Cases	Injured Structure	Name of the Injury	Localization	Situation	Average Time Loss
Shio et al. (2020) [64]	1	Nerves	Severe and persistent nerve palsy	shoulder	Not reported	8 weeks
Maciel et al. (2015) [34]	1	Muscle	Isolated rupture of teres major	shoulder girdle	Ball throwing	2.6 weeks
Lüthje and Nurmi (2002) [79]	1	Bone	Fracture–dislocation of the tarsal navicular	foot	Cross interception	12 weeks
Matsuda et al. (2018) [74]	1	Bone	Femur cam deformity	thigh	Diving save	Unknown/not reported
Resnick et al. (1996) [36]	1	Muscle to bone attachments	Avulsion fracture of the anterior inferior iliac spine	pelvic girdle	Ball kicking	Unknown/not reported
Dunsmuir, McGarrity and Barnes (2009) [22]	2	Bone and muscle to bone attachments	Hematogenous osteomyelitis in the anterior superior iliac spine	pelvic girdle	Not identified	9–13 weeks
Esser et al. (2015) [37]	1	Muscle and muscle to bone attachment	Proximal rectus femoris avulsion	pelvic girdle	Ball kicking	13 weeks
Fysentzou (2016) [63]	1	Muscle	Grade III latissimus dorsi tear	back	Diving save	4 weeks
Mihalik et al. (2005) [69]	1	Bones and teeth	Maxillofacial fractures and dental trauma	head	Not reported	Did not return
Anand et al. (2006) [70]	1	Bones	Complex maxillofacial fractures	head	Not reported	Not reported

#### 4.8. Injury Prevention Strategies

Injuries can lead to the cessation of participation in football activities including goal-keeping training, can slow down career development, as well as cause delayed effects after the end of football career. The injury hazard ratio increases with age, which makes it even more necessary to design preventing programs. The programs should be dedicated to GKs, implemented in training routines and evaluated. Studies on delayed effects of football goalkeeper training and playing should be conducted to describe the possible consequences.

The FIFA 11+ injury prevention program includes three stages with 15 different warm-up exercises performed in the exact order and a specific number of repetitions performed at least twice per week. A systematic review prepared by Sadigursky et al. (2017) revealed that the FIFA 11+ reduced the injury by 30% [90].

About one-third of shoulder injuries are severe and cause time loss over 28 days [23] which strongly justifies the implementation of a preventive program. The Fifa 11+ shoulder injury prevention program for GKs was designed on the basis of the analysis of increasing incidence of upper limb and shoulder injuries [23]. Its effects, however, still need evaluation and assessment.

The injury prevention strategies should aim to decrease overuse and acute injuries rate, lower their burden and, in longer perspective, let preserve better health. It seems even more important for GKs who are reported to live 5–8 years longer than football players in other football positions [91].

### 5. Conclusions

A synthesis of the available literature suggests that football GKs have different injury patterns (type, localization, severity, mechanism, burden) due to their specific characteristics and conditions during game and training compared with outfield players. There are still some controversies whether GKs have the same or lower injury incidence compared to other positions. Still more scientific evidence is needed to prove whether GKs suffer more injuries in training than in matches, but it seems rational due to more goalkeeper-to-player interactions and more goalkeeping actions during training sessions comparing to matches.

The most frequent injuries of football GKs reported in the literature are fractures, luxations and dislocations in fingers, hands, and wrists, as well as muscle and tendon damage in the upper and lower limbs—especially the quadriceps femoris, and forearms muscles and tendons moving hands and fingers. There are also differences in incidence, risk and mechanisms of injuries due to overload-specific risk factors for GKs. The highest injury risk has been evaluated mainly for the upper limbs (shoulder, hand, wrist and fingers), because the most overloading and injury occur during diving saves, ball catches, and direct contact with other players. However, further precise research is needed for an absolute explanation.

#### 5.1. Practical Applications and Recommendation

This narrative review provides some practical applications, which might be used by GK coaches, strength and conditioning coaches, athletic therapists, physical therapist, as well as by GKs themselves. First, the right ball size should be used during training in different age groups, i.e., up to 8 years old (size 3), from 9 to 12 years old (size 4) and from 13 years old and older (size 5). Therapeutic care should consider pain symptoms in the shoulder, wrist, hip, and groin and thigh early, because of high risk of overloading and injury during diving saves, catching and kicking the ball. Furthermore, pain symptoms should not be downplayed as part of the game and should be monitored instead. Such monitoring will allow players, coaches and therapists to understand the true duration and characteristics of pain symptoms.

## 5.2. Future Research Directions

Due to the identified knowledge gaps—injuries and pain in female GKs, young GKs, preventive program designs and their effectiveness, as well as particular injury locations considered to be crucial in field players—knee, groin, and shoulder injuries further research directions are suggested. There is also the lack of research on GK injuries of the head, neck and chest which can be very traumatic. Further research should be directed at the examination of gender and age-related differences in pain and injury mechanisms, based on the injury type and localization in football GKs. To obtain this effect, digital pain mapping can be used to replenish and enrich data assessing injury incidence. Preventive programs should be designed and their effectiveness assessed. Future research should coherently use definitions according to injury definitions described in the Consensus statement [38] to bring findings which would develop knowledge about football GK injuries and improve the prevention programs whose efficiency should be also scientifically evaluated. According to Bahr et al., analysis, not only of injury incidence, but also injury burden [92], is recommended.

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