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REVIEW

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Time-loss and recurrence of lateral ligament ankle sprains in male elite football: A systematic review and meta-analysis

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A literature search was conducted to systematically review and meta-analyze time-loss and recurrence rate of lateral ankle sprains (LAS) in male professional football players. Six electronic databases (PubMed, Scopus, Web of Science, PEDRO, CINAHL, and Cochrane) were searched independently, separately both for time-loss and recurrence from inception until April 30, 2021. In addition, reference lists were screened manually to find additional literature. Cohort studies, case reports, case–control studies and RCT in English language of male professional football players (aged more than 16 years) for which data on time-loss or recurrence rates of LAS were available were included. A total of 13 (recurrence) and 12 (time-loss) studies met the inclusion criteria. The total sample size of the recurrence studies was 36,201 participants (44,404 overall initial injuries; 7944 initial ankle sprain [AS] injuries, 1193 recurrent AS injuries). 16,442 professional football players (4893 initial AS injuries; 748 recurrent AS injuries) were meta-analyzed. A recurrence rate of 17.11% (95% CI: 13.31–20.92%; df = 12; Q = 19.53; I^2 = 38.57%) based on the random-effects model was determined. A total of 7736 participants were part of the time-loss studies (35,888 total injuries; 4848 total ankle injuries; 3370 AS injuries). Out of the 7736 participants, 7337 participants met the inclusion criteria with a total of 3346 AS injuries. The average time-loss was 15 days (weighted mean: 15.92; median: 14.95; min: 9.55; max: 52.9). We determined a priori considerable heterogeneity (CI: 18.15–22.08; df = 11; Q = 158; I^2 = 93%), so that the data on time-loss are only presented descriptively. There is an average time-loss of 15 days per LAS and a recurrence rate of 17%. LAS is one of the most common types of injury with higher recurrence rates than ACL injuries (9%–12%) in professional football players. Nevertheless, the focus of research in recent years has been mostly on ACL injuries. However, the high recurrence rates and long-term consequences show the necessity for research in the field of LAS in elite football. Yet, heterogeneous data lead to difficulties concerning the aspect of comparability.

PROSPERO: CRD42020201577.

KEYWORDS
ankle, football, rehabilitation, sporting injuries, sprains

1 | INTRODUCTION

Ligamentous injuries of the ankle are among the most common types of injuries in sports,[1–9] especially in sports with multi-directional movement patterns.[10–13] Along with muscle (33–35%)[14–17] and knee joint injuries (15%–21%),[14,16–20] trauma to the ankle is the third most common type of injury in professional football.[17,21–23] The injury rate is still high despite a decreasing trend in the injury frequency of ligamentous ankle injuries in professional soccer[24]: 10–18% of the occurring injuries in professional football involve the ankle.[15,17,19,21,25–29] Of this, ligamentous injuries (ankle sprains) account for a large proportion of occurring ankle injuries, with 62–69%.[24–26] More than 75% of ankle sprains involve the lateral ligaments.[24–26]

Previous injuries and inadequate rehabilitation are considered the greatest risk factors for recurrent injuries[14,30–32]: the re-injury rate of ligamentous ankle injuries in sports is increased two- to fivefold,[13,33,34] and especially in soccer up to fivefold.[31,35–39] Persistent symptoms such as feelings of instability, persistent swelling, continuous pain conditions, limited mobility, or cartilage defects can have serious long-term consequences for athletes, and in the worst case, lead to early career dropout.[34,40]

Injury-related time-loss due to initial or recurrent injuries can have significant consequences from many perspectives for various stakeholders (clubs, teams, players, insurances): The team's success depends largely on player availability.[41,42] Long periods of time-loss can therefore have a negative impact on the success of a team and, as a consequence, can be decisive for its performance in the league table and for promotion and relegation. In turn, poor table performance can have important consequences for clubs and indirectly causes high costs.[43] Medical treatment costs directly affect insurance companies. Players, especially elite junior athletes, can be hindered in their athletic development by injury-related time-loss. In addition, an inadequately rehabilitated initial injury, especially in adolescence, is often the beginning of a persistent "injury career".[30]

Lateral ankle ligament injury is still trivialized. Often, the time-loss is less than the time of physiological wound healing.[44] An injury that has not completely healed can have long-lasting consequences (e.g., CAI) and can be a major risk factor for re-injury. Due to differences in study designs, current data on time-loss and recurrence rates of ligamentous ankle injuries in professional football are very heterogeneous. Therefore, this review aimed to systematically compile data on time-loss and recurrence rates of lateral ligamentous ankle injuries in male professional football (soccer). Data on time-loss and recurrence rate can be used as outcome parameters both for practitioners to evaluate the effectiveness of existing concepts and for researchers to evaluate future return to sports approaches.

2 | MATERIAL AND METHODS

All procedures were performed in accordance with the latest PRISMA statement.[45]

2.1 | Search strategy

We conducted a systematic literature search on time-loss and recurrence rates of ligamentous lateral ankle injuries in male professional football players from inception until April 30, 2021 (PROSPERO: CRD42020201577).

2.2 | Study selection and eligibility criteria

Studies had to meet the following inclusion criteria: (1) peer-reviewed; (2) availability of epidemiological data; (3) study type: case reports, case–control studies, case-cohort studies, randomized controlled trials; (4) sex: male; (5) age: >16 years; (6) Level of play: professionals; (7) sports: football (soccer); and (8) injury: lateral ligamentous ankle injuries.

2.3 | Databases and reference lists

We scanned six electronic databases (PubMed, CINAHL, Cochrane, PEDro, Scopus, and Web of Science) during August–September 2020 with the following search terms in Boolean search strategy both for *time-loss* (football OR soccer) AND (elite OR professional) AND (ankle injuries OR ankle sprains OR lateral ligamentous ankle injuries OR lateral ligamentous ankle sprains) AND (time-loss OR time lost injury OR time* OR return*) and *recurrence rate* (football OR soccer) AND (elite OR professional) AND (ankle injuries OR ankle sprains OR lateral ligamentous ankle injuries OR lateral ligamentous ankle sprains) AND

(recurrence* OR reinjur* OR recurrent* OR repeat* OR second*). Reference lists were manually scanned to find additional relevant studies that had not been identified in the electronic databases.

2.4 | Screening process

2.4.1 | Abstract screening

Two independent examiners (ZF, KH) screened title and abstracts. Titles were transferred into an Excel list and were reviewed by the first author (ZF) for accordance. A third author (KDC) was contacted in case of disagreement and decided whether to include the abstract in the full-text screening.

2.4.2 | Full-text screening

ZF screened all of the relevant articles (October/November 2020) for meeting the inclusion criteria using a codebook (Excel file). Relevant articles were screened in a two-step procedure: in a pre-final analysis, evidently irrelevant articles were excluded. In a further final analysis, the remaining articles were screened again. This two-step analysis approach ensured meeting the inclusion criteria. Before data extraction, the second author (KH) screened the articles that passed the final analysis (Appendix S1 and S2).

2.4.3 | Data extraction

Relevant articles for both time-loss and recurrence rate were tabulated by the first author (ZF) in three categories (1) characteristics of included studies; (2) subgroup analysis; (3) results. Subsequently, data were compiled from relevant articles.

2.5 | Quality assessment of reporting quality

A modified version of the STROBE guidelines[46] was used to assess methodological quality and was systematically evaluated using a checklist and data sheet (Appendix S3 and S4). We extracted 11 of the 22 items (Methods: Items 4–9; Results: Items 15, 16; Discussion: 18–20). One point could be given for each item. We defined sub-items as

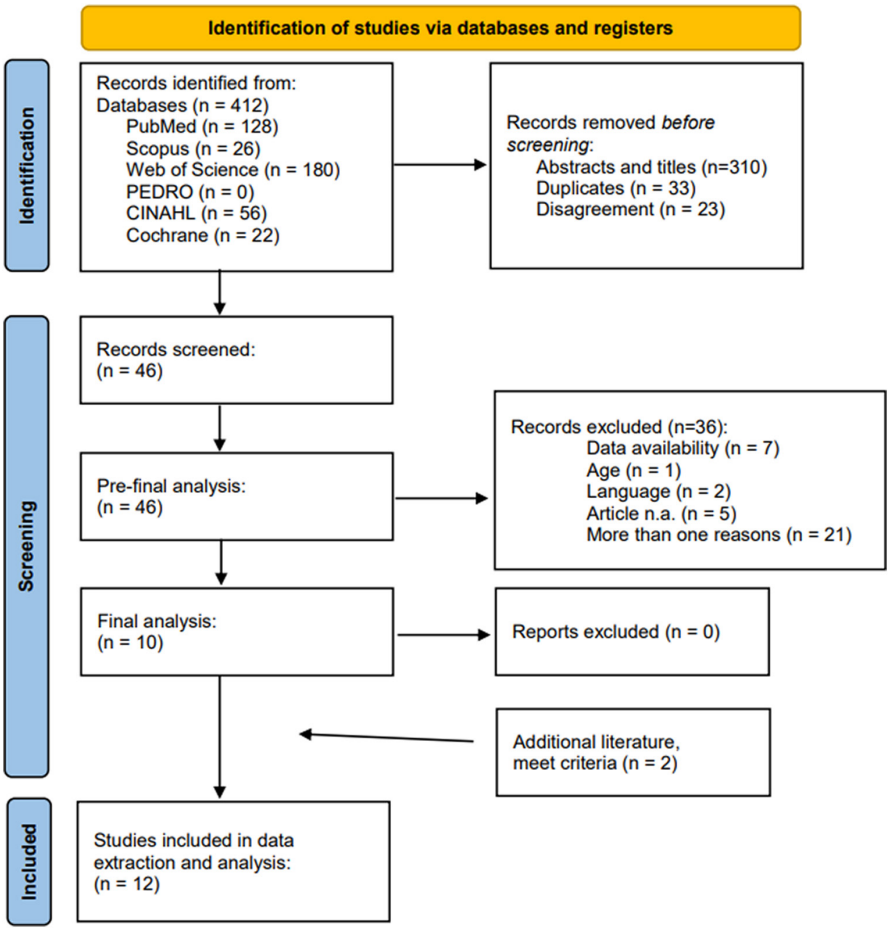

FIGURE 1 Flow-Chart time-loss

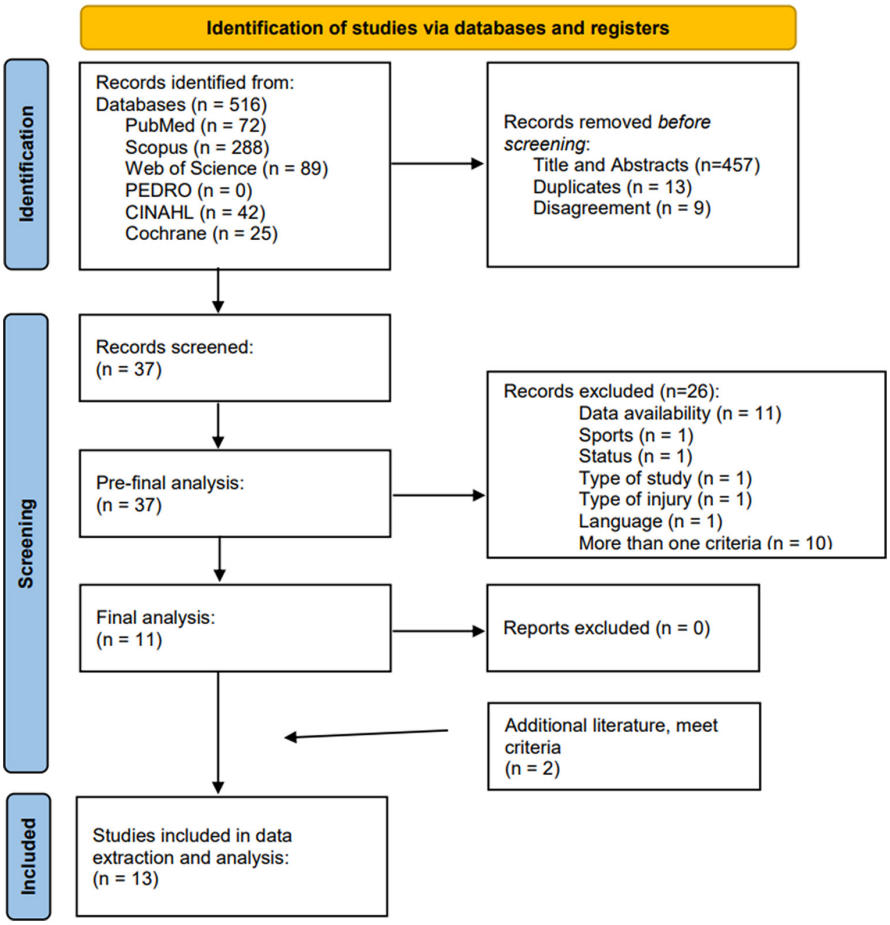

FIGURE 2 Flow-Chart recurrence rate

necessary (N) or facultative (F), respectively. To evaluate an item as 1, all necessary sub-items (N) must be met. We used a range system. Studies within a range of 8–11 points were defined as high quality, 4–7 points as moderate, and 0–3 points as low quality. Two examiners (ZF, KH) evaluated each study independently. In case of disagreement, a third author (KDC) made the final assessment. Modifications of the STROBE guidelines have already been applied in previous reviews.[22,23,47]

2.6 | Dealing with missing data

Data could be calculated if other data were available that allowed an unambiguous calculation. Missing data were requested from the author via e-mail if studies seemed to have useful but not clear reported data. The authors had to respond on request within four weeks. This approach could potentially raise the number of included studies.

2.7 | Data extraction: Systematic review

Separate data extraction sheets were prepared for both outcome parameters of interest (time-loss and recurrence rate). Relevant data on the time of recurrence (early/late) for the outcome parameters were extracted from the studies and entered into these data sheets. The data relevant for time-loss are type of ankle injury, frequency of ankle injury (n+%), frequency of ankle injury in different age-groups (n+%), time-loss (days) in different age groups (n+%), and severity (n+%). The following data of recurrence rate were of interest: type of injury, frequency of ankle injury initial and recurrence (n+%), frequency of ankle injuries in different age groups (n+%), frequency of recurrence in different age groups (n+%), on the time of recurrence (early/late) for the outcome parameters were extracted from the studies and entered into these data sheets.

2.8 | Data extraction and statistical analysis: Meta-analysis

Data on the relevant outcome parameters (time-loss: overall sample size; number of injuries; lost time in days, age; recurrence rate: overall sample size, number of injuries), number of recurrences (n+%) were statistically evaluated.

Only data from the target group (male, age > 16 years–professionals) were calculated in the meta-analysis. The

TABLE 1 Characteristics of included studies. Recurrence rate

General study descriptors											
				Participants							
						Age (years)					
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Mean + SD	Range	Definition of investigated ankle injury	Definition recurrence	Distinction between early and late recurrence (yes/no)	Follow-up time
Amer (2020)	Cross-sectional Study	Professionals + Amateur	Saudi Arabia	*N* = 400 (4 Clubs) *N* = 87 Prof. *N* = 313 Amateur	male	23,2 ± 5,9	18–40 (inclusion criteria)	"Ankle Sprain"	n.a.	no	The results of this study (...) reporting ankle sprain once and more than once within the prior *12 months,* respectively.
Fransz (2018)	Case Control Study Level of evidence: 3	Prof. + Elite Youth	Netherlands	*n* = 190	male	U13: 11,8 ± 0,6 U15: 13,9 ± 0,6 U17: 15,7 ± 0,8 U19: 17,7 ± 0,7 Prof.: 23,2 ± 3,2	n.a.	"Ankle Sprains"	n.a.	no	36 months
Gulbrandsen (2019)	Descriptive epidemiological study	College	USA	**17.025**[a]	male and female	n.a. ("college")	n.a.	"lateral ligament complex tear"	n.a.	no	10 year investigation (survey)
Hawkins (1999)	Prospective epidemiological study	Elite Youth Professionals	England	?	male	n.a.	n.a.	"ankle / sprain" (data calculated)	n.a.	no	n.a.
Jain(2014)	Observational cohort study	Professionals Elite Youth	England	Overall: *n* = 67 Prof.: *n* = 28	male	Youth: n.a. Prof.: 25,1	Youth: n.a. Prof.: 19–35	"ATFL"	n.a.	no	4 year period (2007–2011)
Pourharib-Shai (2020)	Prospective cohort study Level of evidence: 2	Professionals	Iran	Overall: *n* = 106 *N* = 58 (football) *N* = 48 (basketball)	male	19,8 ± 4,5	15–40	"Lateral Ankle Sprain"	n.a.	no	Requestion of injury history of the past two years (Risk of bias: self-reporting)
Price (2004)	Prospective epidemiological study	Elite Youth	England	*N* = 4773 (38 academies)	male	n.a.	9–19	"Ankle" (location) and ligamentous sprains "ATFL"	n.a.	no	
Roos (2016)	Descriptive epidemiology study	College	USA	? n.a.	Male and female	n.a. ("college")	n.a.	"LLC sprains"	n.a.	no	6 year investigation period (2009–2015)

TABLE 1 (Continued)

General study descriptors											
				Participants							
						Age (years)					
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Mean + SD	Range	Definition of investigated ankle injury	Definition recurrence	Distinction between early and late recurrence (yes/no)	Follow-up time
Waldén (2005)	Prospective cohort study	Professionals	Sweden	*N* = 310	male	25	17–38	"Ankle sprain"	"A re-injury was defined as the same type of injury to the same side and location within 2 months after the final rehabilitation day of the previous injury."	no	1 season
Waldén (2013)	Prospective cohort study	Professionals	Europe	*N* = 1743	male	n.a.	n.a.	"Sprain/ligament injury, lateral"	"Injury of the same type and the same site as an index injury occurring within 2 months after return to full participation from the index injury."	no	Teams from varying number of seasons from 2001–2012
Woods (2003)	Cohort study	Professionals	England	*N* = 2376	male	n.a.	17–35	"Anterior talofibular ligament"	n.a.	no	Two competitive seasons (1997–1999)
Hägglund (2016)	Cohort study	EU Top Elite Elite (Prof.) Amateur	EU + Sweden	*N* = 6956 player seasons (Top Elite) *N* = 2014 player seasons (Elite) *N* = 241 player seasons (Amateur)	male	Top Elite 25,4 ± 4,6 Elite 25,2 ± 4,8	n.a.	"Lateral Ankle Sprains"	"Recurrent injury of the same type and at the same side..."	Yes (not for ankle sprains)	Top Elite: 14 years (2001–2015) Elite: 9 years (2001–2011)

(Continues)

TABLE 1 (Continued)

General study descriptors											
				Participants							
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Age (years)			Definition of investigated ankle injury	Definition recurrence	Distinction between early and late recurrence (yes/no)	Follow-up time
						Mean + SD	Range					
Ekstrand (2020)	Cohort study	Professionals	EU + Sweden, Denmark, England, Norway	*N* = ? 116 teams (24 countries)	male	n.a.	n.a.		"Ankle lateral ligament injury"	"A re-injury was defined as an injury of the same type and location as a previous injury."	no	16 years (2001–2017)

meta-analysis was conducted based on the random-effects model[48]: Heterogeneity was both determined by using the Cochran's Q and I^2 test and in addition visually checked by the funnel plot. The following thresholds were set to guide the interpretation of heterogeneity: 0%–40% (not important), 30%–60% (moderate), 50%–90% (substantial), and 75%–100% (considerable).

2.9 | Deviations from the PROSPERO protocol

Only minor changes were made to the PROSPERO protocol. Deviating from the previously defined inclusion criteria, we also included studies that did not include a clear definition of recurrence rate.

3 | SYSTEMATIC REVIEW

3.1 | Results

3.1.1 | Search process

Time-loss

A total of 412 records were identified in six electronic databases whose abstracts and titles were screened. After removing irrelevant studies, a total of 12 studies for time-loss were included in the analysis. The process is shown in Figure 1.

Recurrence rate

In sum, 516 records were identified for recurrence rate. At the end of the screening procedure, a total of 13 studies met the inclusion criteria and were analyzed for recurrence rate (Figure 2).

3.2 | Characteristics of included studies

3.2.1 | Time-loss

Twelve studies from 8 different countries (England (3), EU (3), Brazil (1), Netherlands (1), Spain (1), Turkey (1), Australia (1), and Germany (1)) were analyzed (Table 1). One out of 12 studies examined elite youth players only[49]; two out of 12 studies examined both elite youth and professional players.[50,51] 9 out of 12 studies examined only professionals. Six out of 12 studies made differentiated age statements. Eleven out of 12 studies examined exclusively male football players; one out of 12 studies examined other sports and women in addition to male football players. Data were extractable. All studies included a clear definition of time-loss.

TABLE 2 Characteristics of included studies—Time-loss

General study descriptor										
				Participants						
						Age (years)				
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Mean ± SD	Range	Definition of investigated ankle injury	Definition of time-loss	Definition of severity
Cezarino (2020)	Descriptive epidemiology study / prospective cohort study	Elite Youth	Brazilian	*N* = 228 (total) U11: 23 U12: 22 U13: 25 U14: 28 U15: 28 U16: 25 U17: 28 U18: 16 U20: 33	male	Total: 16.51 ± 2.59 U11: 11.23 ± 0.11 U12: 12.17 ± 0.62 U13: 13.20 ± 0.55 U14: 13.73 ± 3.16 U15: 15.33 ± 0.38 U16: 16.35 ± 0.36 U17: 17.19 ± 0.54 U18: 18.05 ± 0.49 U20: 18.31 ± 2.59	n.a.	"Foot / ankle sprain"	"A player was considered injured until the team's medical staff indicated that he could be fully involved in training and was available for match selection."	"Injury **severity** was defined according to the number of days lost by the player between the day of the injury and return to full participation in team training and match play. For different categories were used: minimal (o-1 days lost), mild (4–7 days lost), mild (4–7 days lost), moderate (8–28 days lost) or severe (>28 days lost)."
Fuller (2006)	Cohort study	Professionals	England	*N* = 55	male	n.a.	20–34	"Ankle Sprains"	"Players were considered to be fit to return to normal team training and competition when they had achieved a 100% recovery score."	n.a.
Fransz (2018)	Case control study Level of evidence: 3	Professionals Elite Youth	Netherlands	*N* = 190	male	U13: 11.8 ± 0.6 U15: 13.9 ± 0.6 U17: 15.7 ± 0.8 U19: 17.7 ± 0.7 Prof.: 23.2 ± 3.2	n.a.	"Ankle Sprains"	"... we considered the number of days that the player was unfit to participate in training or matches after the sprain as a measure of injury severity."	"... we considered the number of days that the player was unfit to participate in training or matches after the sprain as a measure of injury **severity**."
Larruskain (2017)	Prospective cohort study	Professionals (First Division)	Spain	Male: *n* = 50 Female: *n* = 35	male and female	Male: 25 ± 4 Female: 25 ± 5	n.a.	"Ligament injury" "Lateral sprain"	"...unable to participate in future training session or match due to a physical complaint resulting from football training or match play and was considered injured until the medical staff cleared the player for full participation in training and match play."	"According to the number of days lost, injury **severity** was recorded as minimal (1–3 days), mild (4–7 days), moderate (8–28 days) and severe (>28 days."
Oztekin (2009)	Retrospective cohort study	Professionals (registered with the National Football Association of Turkey)	Turkey	*N* = 200 (*n* = 66 ankle injuries)	male	23	17–31	"ATFL sprain" "C/F ligament sprain"	"Time lost from participation was calculated from our own medical records and confirmed by telephone interviews."	"Injury **severity** was defined as days unable to play, and was classified as minor (1–7 days absent from play), moderate (8–28 days absent from play) and severe (>28 days absent from play.)"

(Continues)

TABLE 2 (Continued)

General study descriptor										
				Participants						
						Age (years)				
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Mean ± SD	Range	Definition of investigated ankle injury	Definition of time-loss	Definition of severity
Whalan (2019)	Descriptive epidemiological study/ Prospective cohort study	Sub-elite	Australia	*N* = 1049 (*n* = 25 sub-elite Clubs)	male	24.3 ± 6.2	n.a.	"Ankle ligament sprain"	"Injury that results in a player being unable to fully participate in matches or training. Payers were deemed to have recovered from injury once they had returned to full training / match participation or were considered eligible for team selection."	n.a.
Waldén (2013)	Prospective cohort study	Professionals	Europe	*N* = 1743	male	n.a.	n.a.	"Sprain/ ligament injury, lateral"	"...players were considered injured until the club medical staff allowed full participation in training and availability for match selection."	Slight / minimal: Injury causing 0–3 days lay-off Mild injury: Injury causing 4–7 days lay-off Moderate injury: Injury causing 8–28 days lay-off Severe injury: Injury causing >28 days lay-off
Jain (2014)	Observational cohort study	Professionals Elite Youth	England	Overall: *n* = 67 Prof.: *n* = 28 2nd team: *n* = 18 Youth: *n* = 21	male	Youth: n.a. Prof.: 25.1	Youth: n.a. Prof.: 19–35	"ATFL"	"Injuries defined as an injury that prevented a player being available for selection for at least 5 days. The end oft he injury episode was taken when player was declared as fit for full training or for selection in a match by the medical staff."	n.a.
Woods (2003)	Cohort study	Professionals	England	*N* = 2376	male	n.a.	17–35+	"Anterior talofibular"	"A recordable injury was defined as one sustained during training or competition and which prevented player from participation in normal training or competition for more than 48 hours (not including the day of injury)."	n.a.

TABLE 2 (Continued)

General study descriptor										
				Participants						
						Age (years)				
Study (Author, Year)	Study Type (Design)	Status	Country	Number (*n*)	Sex	Mean ± SD	Range	Definition of investigated ankle injury	Definition of time-loss	Definition of severity
Ekstrand (2013)	Prospective cohort study	Professionals	Europe (10 countries)	*N* = 1743 (27 teams)	male	n.a.	n.a.	"Ankle sprain, lateral"	"The payer was considered injured until the team medical staff allowed full participation in training and availability for match selection."	"Injuries were categorized under four degrees of **severity** based on the number of days absent. All injuries were followed until the final day of rehabilitation." *Sligh / minimal injury:* Injury causing 0–3 days´ absence from training and match play. *Mild injury:* Injury causing 4–7 days´ absence from training and match play. *Moderate injury:* Injury causing 8–28 days´ absence from training and match play. *Severe injury:* Injury causing more than 28 days´ absence from training and match play.
Ekstrand (2020)	Cohort study	Professionals	EU + England, Sweden, Denmark Norway	*N* =? 116 teams 449 team-seasons	male	n.a.	n.a.	"Ankle lateral ligament injury"	"A player's period of absence following an injury constituted the full period (number of days) between the when he the player was forced to discontinue his football participation due to an injury until the date when the medical team allowed the player to return to full participation."	"... mild (leading to a median absence of 7 days or less)... or moderate (median absence: 7–28 days)...severe (median absence >28 days."
Krutsch (2021)	Prospective cohort study Level of evidence: 2	Professionals	Germany (1st Bundesliga)	*N* = 660	male	At injury: 26.3 ± 4.0	17.6–38.6	"Lateral ligament rupture, ankle"	n.a.	"...The analysis of included injury types that resulted in absence from official football matches of at least 28 days and were therefore categorized as 'severe'..."

3.2.2 | Recurrence rate

Thirteen studies from seven different countries (England (4), Saudi Arabia (1), Netherlands (1), USA (2), Iran (1), Sweden (1), and EU (3)) were analyzed (Table 2). One study[52] examined elite youth players only. 2 of 12 studies included both elite youth players and professional players. Only 2 of 13 studies provided differentiated age data. One study[53] included both professionals and amateurs. 3 of 12 studies[54–56] included other sports: of these, 2 of 3 included women.[54,55] Relevant data were extractable from all studies.

3.3 | Results of individual studies for all outcome parameters

3.3.1 | Time-loss

The overall sample size derived from 12 studies is 7736 participants. Two studies do not provide clear information on the sample size.[57,58] Of the 7736 participants, 7701 were male, 35 were female. 6054 participants were professionals (male: 6019; female: 35), 443 elite youth players and 1049 semi-professionals (Table S1).

35,888 overall injuries were recorded of which 4848 (13.5%) were ankle injuries. Of these 4848 overall ankle injuries, 3370 were ankle sprains (69.5%): 3299 ankle sprains occurred in professionals, 71 ankle sprains in elite youth players (47 ankle sprains in the target older age groups). Therefore, a total of 3346 ankle sprain injuries were included in the statistical calculation.

All studies indicate the time-loss as "mean". Five of 12 studies report both mean and median. No study reports only the median, one study reports "average". Each study clearly defines time-loss. In two of 12 studies,[57,58] no clearly differentiated age information is given.

3.3.2 | Recurrence rate

The overall sample size of the 13 studies is 36,201 participants (male: 29,941; female: 9260). Of these, 30,669 were professionals (84.7%), 4979 elite youth players (13.7%) and 554 amateurs (1.5%).

44,404 initial injuries of all anatomical areas were registered, of which 6587 were recurrences (14.8%). Of 40,905 initial injuries, 5966 recurrences occurred in male athletes. 158 recurrences of 1756 initial injuries were recorded in female athletes.

27,174 injuries and 3496 recurrences occurred in professionals (12.8%), 780 initial injuries and 137 recurrences in elite youth players (17.5%) and 7 initial in amateurs. Data on recurrence for amateurs were not available. A total of 7944 initial ankle sprain injuries and 1193 ankle sprain recurrences were identified from all groups, genders, and age groups. Of these, 4893 initial and 748 recurrences were meta-analytically calculated in 16,442 football players (Table 3).

Four of 13 studies clearly define the "recurrence rate". Only one of 13 studies distinguishes between "early" and "late" recurrence. No study distinguishes between "recurrence rate" and "exacerbation".

3.4 | Risk of bias/quality assessment

3.4.1 | Time-loss

None of the included studies were of low quality. While 4 out of 12 (33%) were of moderate quality,[25,50,59,60] 8 out of 12 (66%) were of high quality.[24,49,51,57,58,61–63]

3.4.2 | Recurrence rate

Four out of 13 (31%) of the studies were of moderate quality.[26,50,52,53] Eight out of 13 (61%) showed high quality.[24,27,31,51,54–57] For one study (1 out of 13, 8%) no agreement could be reached on the assessment.[25]

There is a trend towards improved quality assessment through the introduction of recording recommendations. Appendix S5 summarizes the results of the methodological quality assessment.

4 | META-ANALYSIS

4.1 | Statistical analysis

4.1.1 | Data extraction

Recurrence rate

Thirteen studies were included in the meta-analysis as shown in Figures 3 and 4. A sample size of 16,442 players (male, age > 16 years – professionals) was determined in these 13 studies. Four of the 13 studies provide accurate age data for a total of 9587 players. The mean age of this sample is 25.12 (SD = 4.67) years. These 13 studies included a total of 4893 ligament ankle sprains, of which 748 were recurrent injuries. Meta-analytically, a mean and pooled weighted recurrence rate based on the random-effects model of 17.11% (95% CI: 13.31%–20.92%; df = 12; Q = 19.53; I^2 = 38.57%) was calculated. We found moderate heterogeneity (I^2 = 38.57%).

TABLE 3 Results—Recurrence rate

	Participants									Injuries															
							Number of injuries (overall)		Number of AS (overall)		Sex (overall)				Status / Age (overall)						Status / Age (only AS injury)				Data (extracted) for Meta-Analysis	
	Sample size (*n*) (overall)	Sex		Status / Age							male		Fem.		Prof. (*n*)		EY (*n*)		Am.		Prof. (*n*)		EY (*n*)			
Study		Male (*n*)	Fem. (*n*)	Prof. (*n*)	EY (*n*)	Am (*n*)	Init.	Rec.	Init.	Rec.	Init.	rec	Init.	Rec.	Init.	Rec.	Init.	Rec.	Init.	Rec.	Init.	Rec.	Init.	Rec.	Init.	Rec.
Amer (2020)	400	400	0	87	0	313	87	36	87	36	87	36	0	0	87	36	0	0	*n*.a.	n.a.	87	36	0	0	87	36
Fransz (2018)	190	190	0	24	166	0	45	10	45	10	45	10	0	0	0	0	45	10	0	0	3	0	18	6	21	6
Gulbrandsen (2019)	17,025	7765	9260	17,025	0	0	2068	297	1358	297	984	139	1084	158	984	139	0	0	0	0	617	137	0	0	617	139
Hawkins (1999)[a]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	125	31	95	31	95[b]	31	0	0	23	n.a.	8	n.a.	0	0	n.a.	n.a.	n.a.	n.a.	95	31
Jain (2014)	67	67	0	28	40	0	45	11	14	4	45	11	0	0	0	0	0	0	0	0	n.a.	n.a.	n.a.	n.a.	14	4
Pourgharib-Shai (2020)	106	106	0	106	0	0	30	20	30	20	30	20	0	0	30	20	0	0	0	0	30	6	0	0	30	6
Price (2004)[a]	4773	4773	0	0	4773	0	727[c]	127	523[c]	91[c]	727	127	0	0	0	0	727	127	0	0	0	0	523	91	523	91
Roos (2016)[a]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2429	289	2429	289	756	n.a.	672	n.a.	143	20[d]	0	0	0	0	143	20	0	0	143	20
Waldén (2005)	310	310	0	310	0	0	765	180	53[e]	6[e]	53	6	0	0	53	6	0	0	0	0	53	6	0	0	53	6
Waldén (2013)	1743	1743	0	1743	0	0	1080	121	552	38	1080	121	0	0	1080	121	0	0	0	0	552	38	0	0	552	38
Woods (2003)[a]	2376	2376	0	2376	0	0	1011	n.a.	677	61[f]	1011	n.a.	0	0	1011	n.a.	0	0	0	0	677	61	0	0	677	61
Hägglund (2016)	9211	9211	0	8970	0	241	13,050	2449	821	138	13,050	2449	0	0	821	138	0	0	7	n.a.	821	138	0	0	821	138
Ekstrand (2020)	n.a. (116 teams)	n.a.	n.a.	n.a.	n.a.	n.a.	22,942	3016	1260	172 (13.7%)	22,942	3016	0	0	22,942	3016	0	0	0	0	1260	172	0	0	1260	172
Total	36,201	26,941	9260	30,669	4979	554	44,404	6587	7944	1193	40,905	5966	1756	158	27,174	3496	780	137	7	n.a.	4243	614	541	97	4893	748

Abbreviations: Am, Amateur; AS, Ankle Sprain; EY, Elite Youth; Fem., female; Init., initial; n.a., not available; Prof., Professionals; rec., recurrence.

[a]Missing data were calculated.

[b]Hawkins (1999): 76% out of 125 = 95.

[c]Price (2004): 19% out of all injuries = 727; 72% out of 727 = 523 ankle sprains; 72% out of 127 re-injuries = 91 re-injuries (ankle sprains).

[d]Roos (2016): 14% out of 143 = 20; only includes sports in which both sexes participated.

[e]Waldén (2005): 99 sprains; out of 99 sprains were 54% ankle sprains (=53 ankle sprains); 11% out of 53 were recurrent ($n = 6$).

[f]Woods (2003): "re-injury rate of AS was 9%"; 9% out of 677 = 61.

Time-Loss

Twelve studies were included in the meta-analysis. A sample size of 7293 players (male, age > 16 years – professionals) was determined in these 12 studies. Six of 12 studies included specific age data for a total of 2013 (1849 professional; 164 elite youth) players. The average age determined is 23.91 (SD = 4.99) years. An a priori assessment of heterogeneity found "considerable heterogeneity" (20.11 days; 95%CI 18.15–22.08; df = 11; Q = 158.19; I^2 = 93.05%). Due to "considerable heterogeneity" we decided to perform descriptive statistics for the time-loss outcome parameter. There were 3346 ankle sprains (Professionals: 3299; Elite Youth: 47) in the 12 included studies. We found the weighted mean time-loss is 15.92 days (median: 14.95; minimum: 9.55; maximum: 52.9).

5 | DISCUSSION

To our knowledge, this is the first systematic review to explicitly examine the time-loss and recurrence rate after lateral ankle ligament injuries in professional football players. The overall aim of this systematic review was to determine time-loss and recurrence rates after LAS in elite football players. Among other things, these can serve as outcome parameters for testing the effectiveness of future rehabilitation concepts.

5.1 | Main findings

5.1.1 | Time-loss

We determined an average time-loss of 15.92 days (MD: 14.95; Min: 9.55; Max: 52.9) following lateral ankle ligament injury. Even though only one of the included studies[58] explicitly investigated severe injuries (ruptures), it should be critically noted that wound healing of the ligaments is still incomplete with time losses of about 15 days,[44] especially for higher grade ankle sprains with structural damage. Ligaments need adequate tissue loading in rehabilitation training sessions for remodeling and maturation to attain adequate stability.[64] On the one hand, this physiological process is time-based and unlikely to be complete with time-loss of 15 days leading to professional football players returning to competitive sport with incomplete healing of the ligament structures. On the other hand, this highlights the need for criteria-based functional rehabilitation which should be independent of time. Time-loss of 15 days raises doubts as to whether the duration of the rehabilitation period is sufficient to gradually restore sport-specific function to pre-injury levels. Athletes should not return to sport until specific criteria are met and original movement patterns are restored. Compensatory movement behavior due to unhealed injuries by an insufficient rehabilitation period are risk factors for secondary injuries.[65]

Therefore, approaches to functional rehabilitation based on specific criteria fulfillment for RTC were developed for knee and muscle injuries.[66–69] Such approaches are still lacking for ankle injuries.[70,71] In this context, the use of pain-relieving drugs for the fastest possible RTC should also be critically discussed. Neither subjectively reported absence of pain nor time should be decisive factors in determining RTC.

5.1.2 | Recurrence rate

We determined a recurrence rate of lateral ankle ligament injury in competitive football players of 17%. Even though

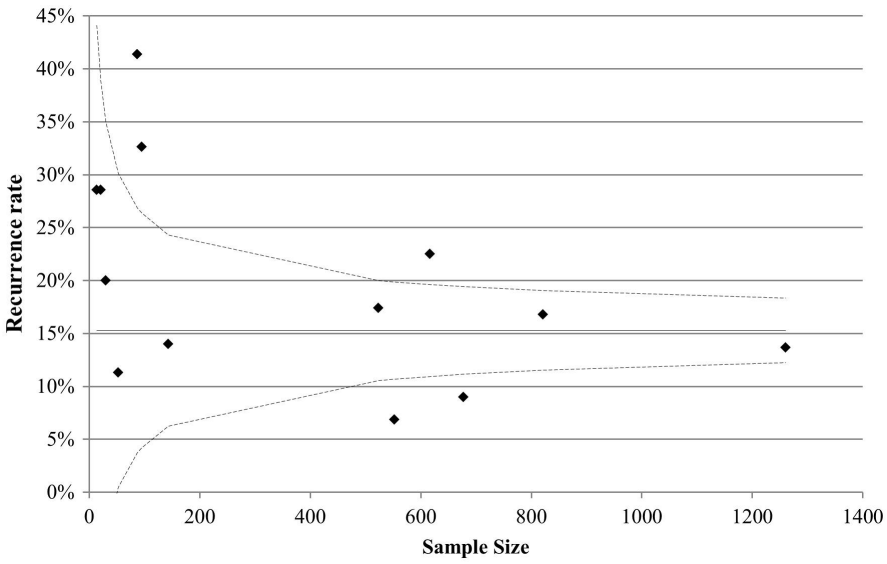

FIGURE 3 Funnel Plot Recurrence rate

Study	Recurrence rate (95% CI)
Amer (2020)	41.38% (27.86-54.90%)
Ekstrand (2020)	13.65% (11.61-15.69%)
Fransz (2018)	28.57% (5.71-51.43%)
Gulbrandsen (2019)	22.53% (18.78-26.27%)
Hawkins (1999)	32.63% (21.14-44.12%)
Hägglund (2016)	16.81% (14.00-19.61%)
Jain (2014)	28.57% (0.57-56.57%)
Pourgharib Shahi (2020)	20.00% (4.00-36.00%)
Price (2004)	17.40% (13.82-20.97%)
Roos (2016)	13.99% (7.86-20.12%)
Waldén (2005)	11.32% (2.26-20.38%)
Waldén (2013)	6.88% (4.70-9.07%)
Woods (2003)	9.01% (6.75-11.27%)
Pooled	**17.11% (13.31-20.92%)**

df=12, Q=19.53, I^2=38.57%

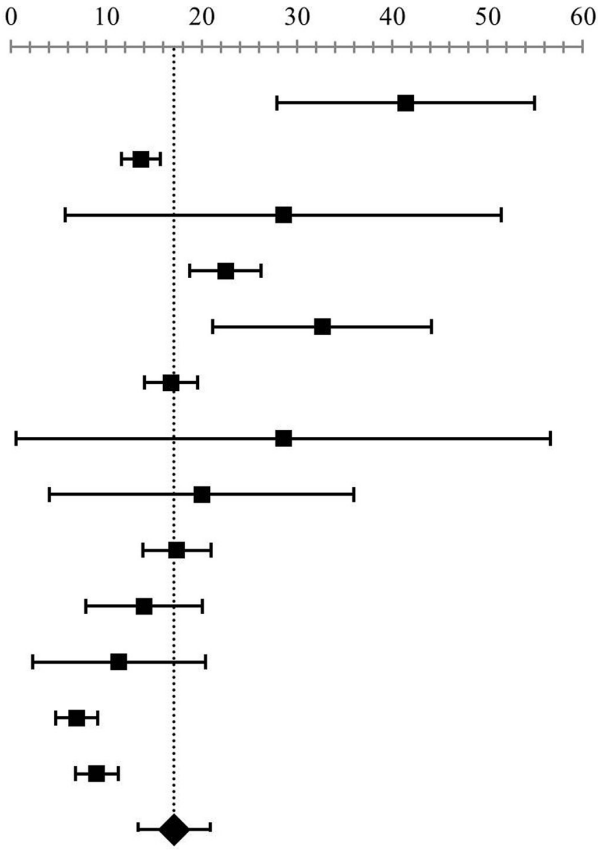

FIGURE 4 Forrest Plot Recurrence rate

this is a higher recurrence rate of ACL injuries (9%–12%) in professional football,[27,72,73] a major focus of research was on ACL injuries in the past. Thus, there is a need to fill the gap in research of LAS, especially in the question of reasons for the high rate of recurrent ankle injuries in professional football players. In addition to a possible insufficient healing time (cf. time-loss), healing and tissue stability, the causes of high recurrence rates can be suspected in neuro-plastic alterations. Injuries change the movement pattern at the corticospinal level and influence postural control mechanisms.[74–76] This could affect protective mechanisms to prevent further trauma (e.g., prolonged latency).[77,78] This could explain why a previous injury is one of the greatest risk factors for a subsequent injury.[30] We could not identify in this review whether the recurrences occurred at an early or late time point. However, morphologic alterations in axons at early time points after injury have been described.[75] Thus, with knowledge of the timing of recurrent injuries, more specific prevention programs could be developed based on neuroplastic research findings. Longer rehabilitation periods after ACL injuries, however, offer the possibility to gradually eliminate deficits and to restore original movement pattern.

Ankle injuries are often trivialized.[79] Financial pressures can lead to athletes and medical staff encounter severe pressure from the club's management and coaching staff to return athletes to play as quick but may not be as safe as possible. Coaching staff is pressured to succeed and to win titles. Thus, coaches may put pressure on athletes to risk their own health and long-term consequences for short-term success.[80] This often leads to conflicting situations between medical staff and head coaches.[81] Head coach's leadership style and trustworthy internal communication between the medical team and the head coach are important factors in reducing injury risk. Teams with high internal communication quality had lower injury rates and higher player availability than teams with low communication quality.[82] This could explain the connection between the short duration of absence and the increased recurrence rate for these injuries, especially since every form of injury must be considered a "systemic injury" with consequences at the cortical level (e.g., altered movement pattern).

On the one hand, Ekstrand[63,83] describes a decreasing trend in the occurrence and recurrence rate for all types of injuries as well as for ligament injuries in elite football players. However, our review could not confirm this decreasing trend for ankle ligament injuries. The authors attribute the decreasing trend, among other things, to improved treatment and rehabilitation concepts.

Nevertheless, the recurrence rate of 17% after LAS appears high. Recurrence rates above the initial injury rate should give rise to discussion and, despite improved rehabilitation measures, the effectiveness of current rehabilitation concepts should be questioned especially in supposedly minor low-grade ankle sprains. Malliaropoulos[84] shows in his study that in particular low-grade ankle sprains show high recurrence rates. They ascribe this, among other things, to the trivialization of the injury and the insufficient duration of rehabilitation. Rehabilitation is mostly still time-based and controlled by the experience of the physician and therapist. Although guidelines for RTC decisions have been developed in the past,[85] there are currently few criteria-based step-by-step approaches to guide the rehabilitation.

Reducing recurrence rates after LAS has benefits for many stakeholders (player, team, club): injury-free teams are proven to be more successful.[41] The availability of key players, in particular, can determine matches, and thus, the outcome of the standings (table position) and, ultimately, promotion or relegation. A correlation between injury-related time-loss and costs incurred has been identified both globally[43] and specifically in relation to ankle injury.[86] For professional players, a repeatedly long period of time-loss often means fewer practice and a possible loss of their regular place, which is often accompanied by significant decrease of their market value and may put players into disadvantageous negotiating positions for new contracts.

5.2 | Reporting quality/reporting bias

We used a modified form of the STROBE guidelines to assess the reporting quality of included studies.[46,87] The majority of studies were of moderate to high reporting quality. More recent studies published after the establishment of consensus agreements on data recording tended to have better reporting quality. This could indicate the successful establishment of uniform recording recommendations through consensus statements. Nevertheless, the original STROBE assessment appears to be suitable only to a limited extent, since not all of the 22 items or their sub-items appear to be suitable for assessing the reporting quality of individual questions of systematic reviews. The use of a pure sum score to assess the quality of reporting seems unsuitable, as individual items can have different importance. This approach is quite imprecise. Nevertheless, it offers an approximation for assessing the reporting quality of included studies. Critically, it should be noted that the procedure refers purely to the assessment of reporting and does not represent a report on the methodological quality of the study itself.[88,89] Even methodologically poorly conducted studies can be well reported, and vice versa. Nevertheless, modified STROBE guidelines are obviously also indirectly suitable for assessing study quality.[89] The lack of a quality assessment for observational studies led us to develop our own approach. Therefore, we decided on a "range-solution". Various systematic reviews use modified versions for quality assessment.[22,23,47] This indicates the need for future development of specific assessment methods to assess quality of observational studies.

5.2.1 | Confounder of reporting

We were able to identify only a few studies from which we could determine the time-loss or recurrence rates after lateral ligament injuries of the ankle in professional football players. This finding confirms the results of Lopez-Valenciano et al.,[23] who found it was not feasible to conduct a subgroup analysis on the time-loss of different types of injuries in professional football due to a lack of data. In addition, the heterogeneous data situation of non-uniform recording methods makes the comparability of individual study results difficult. For this reason, eleven consensus papers on processes of homogeneous data collection have been produced since 2005 in order to establish better reporting standards for epidemiological studies in the future.[90,91]

Subgroup analysis

Only a few of the included studies (time-loss 6/12; recurrence rate 2/13) provide specific age information, so that we could not conduct a subgroup analysis of the outcome parameters (time-loss; recurrence rate) between professionals and elite youth players. Thus, future studies should present differentiated information on age. An overview of injury occurrence (e.g., exposure, prevalence, incidence, recurrence rate, time-loss, and severity) of different age cohorts can help to detect injury patterns at certain career points and to develop target-oriented prevention programs. Originally, we planned a differentiated subgroup analysis of different ankle ligaments. However, only a few studies (recurrence: 2/13; time-loss: 3/12) present data of interest of different lateral ligamentous structures, so we could not perform a subgroup analysis of specific ligament structures. Future studies should also provide information on anatomical structures to specific time-loss for individual ligaments to improve prevention for reduction of recurrence rates.

Inconsistent definitions

Inconsistent definitions make it difficult to compare study results: while 12 out of 12 studies described a clear definition for time-loss, only 4 of 13 studies clearly defined

"recurrence". This reporting bias can lead to inconsistent results and should be taken into account when interpreting the results of this review. This finding highlights the need for uniform definitions in the future for comparability of results. Similarly, only one study[31] differentiate between "early" and "late" recurrence: by knowing more precisely the timing of recurrence, more effective prevention strategies could be developed that take into account vulnerable phases. The timing of vulnerable phases for recurrence appears to be better researched in ACL injuries, among others.[92–94]

Exacerbation versus recurrence

No study differentiates between "exacerbation" or "recurrence": future studies focusing on issues of recurrent injury causation should also include sub-categories of recurrence and exacerbation to ultimately establish better RTC decision models.[95] Inclusion of exacerbation-category specified data. Accordingly, a re-injury suffered during rehabilitation before the RTC would not be recorded as a "recurrence" but as an "exacerbation". This definition implies a possible prolonged time-loss and should be critically considered under this aspect. Nevertheless, an integration of this sub-category ("exacerbation") seems advisable. This should initially be integrated additionally in future studies so that the data on existing studies remain comparable.

6 | STRENGTHS

This systematic review followed a clear methodological approach based on the current PRISMA guidelines,[45] it was registered on PROSPERO prior to literature searching and at least two authors (ZF, KH) assessed relevant data independently.

A strength of this systematic review lies in the specificity: we included only studies that provide data on time-loss and recurrence rates of lateral ankle ligament injuries in male professional football players. Many studies present the data non-specifically by location ("ankle"). Based on the aim to specifically investigate lateral ligament injuries, we excluded studies of a global presentation ("ankle").

Another strength is the large sample size of participants and injuries examined for both time-loss and recurrence rate, which makes the results of this systematic review very robust.

7 | LIMITATIONS

Despite following the latest PRISMA guidelines and PROSPERO registration, there were still some limitations of our systematic review. Firstly, we included some studies that did not clearly define age or status. Data on elite or professionals classified participants as "adults". We also classified college athletes as "professionals". Secondly, as it is often not possible to differentiate between different ligamentous ankle injuries from the study data, we included all types of ankle sprains based on the knowledge that approximately 75%–90% of all ankle sprains affect the lateral ligaments.[24–26] In contrast to what was registered on PROSPERO, we also included studies that did not (or did not clearly) define "recurrence". Adhering to this criterion would have drastically reduced the number of studies for the analysis. On a rather critical note, the overall comparability is limited due to the lacking definition of "recurrence". It should also be considered that we only included study data from male professional football players, so that our results are not generalizable to other cohorts (e.g., female, amateur, non-elite, younger age) and the results must be interpreted within this context.

8 | PERSPECTIVE

The results of this systematic review on time-loss and recurrence rate can be used as outcome parameters to evaluate the effectiveness of existing concepts. On the one hand, practitioners can use them as "guideline values" to evaluate their own approaches. On the other hand, the results can be helpful in convincing athletes and especially coaches of the need for adequate function-based rehabilitation, even though this may mean a potentially longer rehabilitation period. In particular, coaches are pushing for an early return of their key players. The risk of re-injury with the knowledge that a subsequent injury means not only a renewed but mostly also prolonged time-loss, can be a strong argument towards coaches for accepting a longer rehabilitation period, especially if they push (also being under external pressure) for an early RTC. Elite youth players in particular should not return to competition with physiologically unhealed ligament structures, which is a major responsibility for medical teams.

Finally, researchers can use the results of this systematic review of the outcome parameters as a basis for prospective planning and evaluation of the effectiveness of future rehabilitation concepts.

9 | CONCLUSION

Lateral ankle ligament injuries are one of the most common types of injury in professional football. The time-loss

averages 15 days and is thus below the necessary time for physiological wound healing. The high recurrence rate of 17% raises the question whether the duration of the rehabilitation period is sufficient to gradually restore sport-specific function to pre-injury levels. These findings highlight the need for criteria-based rehabilitation concepts. Data on time-loss and recurrence rate can be used as outcome parameters to evaluate the effectiveness of rehabilitation algorithms, based on this systematic review's result. Nevertheless, the heterogenous data recording of individual studies complicates the general comparability of the study results which highlights the need for future homogenous data recording in football injury studies.

AUTHOR CONTRIBUTIONS

ZF and KH selected the studies. KDC decided in case of disagreements. ZF extracted and analyzed the data, was responsible for conception and design, and drafted the manuscript. KH and KDC revised the manuscript. All authors commented on the paper and approved the final version.

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CONFLICT OF INTEREST

There are no competing interests for any author.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PATIENT INVOLVEMENT

The study does not involve identifiable patients.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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