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Criteria for return to play after ACL injury in women's soccer: a scoping review

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Criteria for return to play after ACL injury in women's soccer: a scoping review

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À família e amigos que sempre apoiaram esta decisão e me incentivaram durante todo o processo,

A todos, muito obrigada.

Resumo

Contexto: O futebol feminino é um desporte em crescimento e com isso o número de lesões, incluindo a rutura do ligamento cruzado anterior (LCA), também aumentou. Uma vez que este tipo de lesão tem um impacto financeiro e no desempenho desportivo das equipas e atletas, é pertinente definir um conjunto de critérios que ajudem num melhor e mais seguro return to play (RTP).

Objetivo: Definir critérios de RTP após lesão do LCA no futebol feminino.

Métodos: A scoping review foi realizada utilizando a PRISMA Extension for Scoping Reviews (PRISMA-ScR), em 11 de junho de 2023. Esta pesquisa foi realizada em três plataformas: PubMed, PEDro e Science Direct, utilizando termos similares a "feminino", "futebol", "ACL" e "return to play". Para serem incluídos os estudos devem ter amostra exclusiva de jogadoras de futebol feminino com histórico de lesão do LCA. Quanto aos resultados, foram analisados diferentes parâmetros e as formas de os avaliar.

Resultados: Foram incluídos oito dos setecentos e seis artigos identificados. A maioria dos estudos utilizou bateria de hop tests ou análise de movimento como critério de RTP, mas vários outros parâmetros também foram considerados. A avaliação dos parâmetros encontrados foi realizada de diferentes maneiras, sendo as medidas mais comuns a percentagem de LSI e os dados de performance pré-lesão, quando disponíveis. A maioria dos estudos aconselha a utilização de baterias de testes, com inclusão de diversos parâmetros, para a tomada de decisão de RTP.

Conclusão: A literatura que estuda os critérios de RTP após lesão do LCA, em jogadoras de futebol feminino, é muito limitada. Os estudos analisados parecem concordar que uma bateria de testes é a melhor forma de avaliar a preparação das jogadoras para RTP, mas os testes que devem ser incluídos ainda não estão definidos. Assim, são necessários mais estudos nesta população para definir um conjunto de testes que permita uma RTP de sucesso.

Palavras-chave: Feminino; Futebol; ACL; Return to Play

Abstract

Context: Female soccer is a growing sport and with that, the number of injuries, including anterior cruciate ligament (ACL), is also rising. Because this kind of injury significantly impacts the financial and sports performance of the teams and athletes, is pertinent to define a set of criteria that helps in a better and more safe return to play (RTP).

Objective: Define Return to play criteria after ACL injury in female soccer.

Methods: The scoping review was conducted using PRISMA Extension for Scoping Reviews (PRISMA-ScR), on June 11th, 2023. This research was done on three platforms: PubMed, PEDro and Science Direct, using terms related to "women", "soccer", "ACL" and "Return to Play". To be included the studies should have an exclusive female soccer player sample and athletes had to have an ACL injury. As for the outcomes, the different parameters, and the ways of measuring them, were analyzed.

Results: Eight out of the seven hundred and six identified articles were included. Most studies used hop test batterie or movement analysis as an RTP criteria, but several other parameters were also considered. The evaluation of the finding parameters was conducted in different ways, the more common measurement were the LSI percentage and data from pre-injury performance when available. Most studies advised the use of test batteries, with the inclusion of different parameters, for making an RTP decision.

Conclusion: The literature on RTP criteria after an ACL injury, in female soccer players, is very limited. The studies seem to agree that a batterie of tests is the best way of assessing the players' readiness to return to play, but the tests that should be included are not yet defined. Therefore, more studies with this population are required for further conclusions.

Keywords: ACL; RTP; women; soccer

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Abbreviation List

ACL	Anterior Cruciate Ligament
ACL– QoL	Anterior Cruciate Ligament- Quality of Life
ACL– RSI	Anterior cruciate ligament- Return to Sport after Injury
ACLR	Anterior Cruciate Ligament Reconstruction
CMJ	Countermovement Jump
DVJ	Drop Vertical Jump
FIFA	Fédération Internationale de Football Association
IKDC	International Knee Documentation Committee
LSI	Limb Symmetry Index
OCEBM LoE	Oxford Centre for Evidence-Based Medicine Levels of Evidence
PICOS	Participants, Intervention, Comparator, Outcomes, Study Design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROM	Patient-Reported Outcome Measures
RTP	Return to Play
SMPS	Sport Multidimensional Perfectionism Scale
SPP	Swedish Universities Scales of Personality
USA	United States of America

1. Introduction

The participation of female athletes in sports has increased over the last decade (Webster, 2021 & Griffin, 2020 & Crossley, 2020). Women's football has also seen a significant increase in the number of participants, currently counting (Crossley, 2020 & Valenti, 2018) more than 13 million, according to Fédération Internationale de Football Association (FIFA) (Bakare, 2021 & Randell, 2021). The reduced number of studies on the biomechanics of women's football, the lack of guidelines, training and prevention programs, and the increase in physical and performance demands, combined with the growth in sports practice at younger ages, (Bram, 2020) may have increased the number of injuries. (Gianakos, 2022 & Memon, 2018 & Lidanger, 2019).

The athletes' goal after an anterior cruciate ligament (ACL) injury is to quickly return to their pre-injury performance level. However, the literature mostly studies male players, with data on female athletes tending to be underrepresented (Brinlee, 2022 & Taberner, 2020 & Webster, 2021), even with the incidence of injury being 2.2 times higher in women's football (2/10000h of exposure) when compared to men's (0.9/10000h) (Owoeye, 2020). Injuries in football, regardless of the sporting level, mostly occur in the lower limb (Bakare, 2021), including injuries to the knee joint. An ACL injury implies a high economic burden for teams, as it causes a prolonged layoff for the athlete (Ross, 2023 & Dai, 2014), with inferior knee-related outcomes in females than male athletes. (Bruder, 2023).

The ACL's main function is to stabilize the knee and limit hyperextension. (Calvo Fernández, 2022 & Golan, 2019 & Prado, 2019), when the ligament is compromised there is a loss of these functions, leading to joint instability (Hassebrock, 2020). The injury occurs due to anteriorization of the tibia, through contact, more common in male athletes, or without contact, representing 70% of injuries in female athletes (Calvo Fernández, 2022). Rapid deceleration movements and change of direction are the most common injury mechanisms. (Parsons, 2021 & Olivares-Jabalera, 2021)

The etiology of ACL injuries in female athletes is multifactorial (Zago, 2021), with some differences when compared to male athletes (Calvo Fernández, 2022 & Hohmann, 2021 & Parsons, 2021 & Dauty, 2022). Female athletes have a narrower femoral intercondylar fossa, increased anterior inclination of the tibial plates (Hohmann, 2021 & Parsons, 2021 & Dauty, 2022 & Calvo Fernández, 2022), and higher ligament laxity, associated with a higher concentration of estrogen (Hansen, 2016). A dynamic knee valgus, present in the technical gesture of women's football, due to the increase in the Q angle, can cause lateral oscillations of the mass center at landing and increase the athlete's risk for injury (Della Villa, 2020 & Calvo Fernández, 2022 & Zago, 2021 & Zebis, 2015). Decreased muscle strength in the lower limb can predispose the athlete to ACL injury, as it is also associated with dynamic knee valgus during single-leg landing. (Collings, 2022).

In athletes, it is usual to choose surgical ligament reconstruction via arthroscopy, instead of the conservative approach. (Gallaga, 2022) In reconstruction surgery can be used autografts removed from the hamstring or patellar tendon, which are associated with greater vulnerability of the extraction place (Wu, 2022 & Matiola, 2022), or allografts/synthetic grafts, associated with higher levels of rejection (Matiola, 2022 & Satora, 2017). The healing process can occur up to 2 years after surgery, this being the period in which there are more reinjuries (Brinlee, 2022). Athletes who return to competition before 9 months are 7 times more likely to tear their ACL again, and it is advised to only return after this period (Brinlee, 2022 & Badawy, 2022).

The rehabilitation program must be solid, to return the player to the pre-injury competitive level, and should be started immediately after surgery, to restore neuromuscular function and restart specific training for the sport (Brinlee, 2022 & Almeida, 2018). Earlier rehabilitation is associated with better clinical, functional, and performance outcomes, both in the short term and 2 years after the intervention (Brinlee, 2022 & Badawy, 2022 & Grindem, 2015). According to the most recent guidelines, immediate knee mobilization and strength/neuromuscular training should be implemented postoperative, using exercises with body weight, in a closed and open chain. Cryotherapy, hydrotherapy, electrostimulation, and core strengthening can also be used, depending on the individual circumstances of each player and the presence of other associated injuries. (Andrade, 2020 & Kotsifaki, 2023 & Badawy, 2022). Passive mobilization is not recommended, as it does not present significant improvements in the recovery progression (Andrade, 2020). Rehabilitation must consider tissue healing time, but progression criteria must be defined based on the assessment of ROM, pain, swelling, and muscle strength (Brinlee, 2022 & Badawy, 2022). Establishing realistic objectives allows for the creation of checkpoints that guide the progression of the rehabilitation process (Cavanaugh, 2017). In football, physical, technical, and tactical skills are necessary (Almeida, 2018), therefore, the last phases of rehabilitation must be carried out in a team and field context (Brinlee, 2022).

The mental components, including motivation, recovery expectations, fear of reinjury, self-esteem (Vutescu, 2021), and stress and confidence levels, are extremely important for a successful return to play (RTP) and must be periodically assessed, using, for example, the

Anterior Cruciate Ligament – Return to Sport After Injury (ACL-RSI) questionnaire (Brinlee, 2022), kinesiophobia, pain catastrophizing or fear of reinjury, can impede the athlete's progression (Badawy, 2022). Educating the player about the surgery and recovery process, as well as setting realistic goals, can increase adherence to the rehabilitation process (Badawy, 2022 & Brinlee, 2022).

The RTP rate after ACL reconstruction in elite women's football is 82%, however, 25% end up relapsing (Webster, 2021 &). This scoping review aims to contribute to the definition of objective criteria for RTP, reducing the risk of recurrence (Brinlee, 2022), reducing the dropout rate, and contributing to the return to the previous level of performance (Swart, 2014).

2. Methods

Scoping reviews are exploratory projects that systematically map the literature available on a topic, identifying key concepts, theories, sources of evidence, and gaps in the research. They are particularly helpful when the literature is heterogeneous and can be used to develop a research agenda and identify areas for future systematic reviews or other types of evidence synthesis (Peters, 2020). Therefore, considering the research question, this method was used to conduct the present study.

2.1. Literature Search Approach

The present scoping review was conducted in agreement with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-2020) guidance (Page, 2021). The reviewers framed the research question based on the FINER criteria (Aslam, 2010). Research was conducted on the following health and science electronic databases: PubMed, Science Direct, and PEDro (Physiotherapy Evidence-Based Database) by two reviewers. A general search was led to gather an overview of the available information on this topic, including a combination of the terms 'ACL' AND 'RTP' AND 'soccer' AND 'female', This research was essential to design the search strategy. The final search was carried out on June 11th, 2023, using the same strategy on two databases (PubMed, PEDro), including the keywords 'woman (OR female)', 'soccer (OR football)', and 'anterior cruciate ligament (OR ACL) ´. For the last database (Science Direct) the keywords 'return to play (OR RTP)' were added to the previous ones. The searching expression for each database is available in Table 1. The bibliographic references of the included articles were also analyzed for potential articles that could be relevant to this study.

Table 1: Information sources and search strategy

Database	Search fields	Search terms (database subject headings)
PubMed PEDro Science Direct	Title, abstract, keywords, full text	1- (Woman OR female) 2- (Soccer OR football) 3- (Anterior cruciate ligament OR ACL) 4- (Return to play OR RTP) 5- PubMed e PEDro (1 AND 2 AND 3) 6- Science Direct (1 AND 2 AND 3 AND 4)

2.2. Eligibility Criteria and Quality Assessment

The selection criteria were defined using PICOS (participants, intervention, comparator, outcomes, study design) (Amir-Behghadam, 2020), language, and article access. A detailed description of these criteria is presented in Table 2.

To assay the level of evidence of each article, the reviewers used the Oxford Centre for Evidence-Based Medicine Levels of Evidence (OCEBM LoE). This method classifies articles in five different levels of evidence, from 1 (higher) to 5 (lower). A higher level of evidence means a higher quality study (Howick, 2011).

Table 2: Eligibility criteria for included studies

Inclusion criteria	Exclusion criteria
(P) – Female soccer players (I) – Group with ACL injury (C) – Healthy knee players or none (O) – Parameters for RTP (S) – All Language – English, Portuguese, Spanish	Surgical treatment to other knee ligaments Never being a soccer player Other languages

2.3. Selection of Sources of Evidence

The original search was executed by two independent reviewers who analyzed the title and abstract of the founded articles. A first selection was made, and the articles that perceptibly did not meet the inclusion criteria were excluded, in case of doubt the article was not excluded. In case of doubt a third opinion was considered. In Figure 1 it is possible to examine the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart that was used as a base for this selection process (Page, 2021). At the next step, the reviewers analyzed the full text of the remaining articles and the ones that didn't entirely meet the inclusion criteria were excluded. The remaining articles will be the base of this study.

2.4. Outcome Extraction

After the selection process, the remaining articles were analyzed, and the relevant data was extracted and organized by category, in a chart (Table 3 & 4). The categories that were considered pertinent to assist in the development of this scooping review were: author, year of publication, sample data (size and mean age), control group characterization (size, mean age, and criteria), study type, level of evidence and criteria to RTP (parameters, tests, and tests outcomes).

3. Results

The literature search (ran on June 11th, 2023) resulted in a total of 706 articles. After removing the duplicates, the title and abstract of the remaining 632 articles were screened and 544 were excluded. The full text of the remaining 88 articles was analyzed and assessed for eligibility criteria. 80 articles were removed for the following reasons: Twenty-nine didn´t specify RTP criteria, twenty-four used athletes from several sports, seventeen used both female and male soccer players, 2 used only male athletes, six used healthy athletes, one was written in French and one was not available. Therefore, a total of 8 relevant articles were identified. This information is summarized in the PRISMA flowchart (Fig. 1). The information that characterizes the eight included studies is available in Tables 3 and 4. The complete list of included articles is available in Appendix 1.

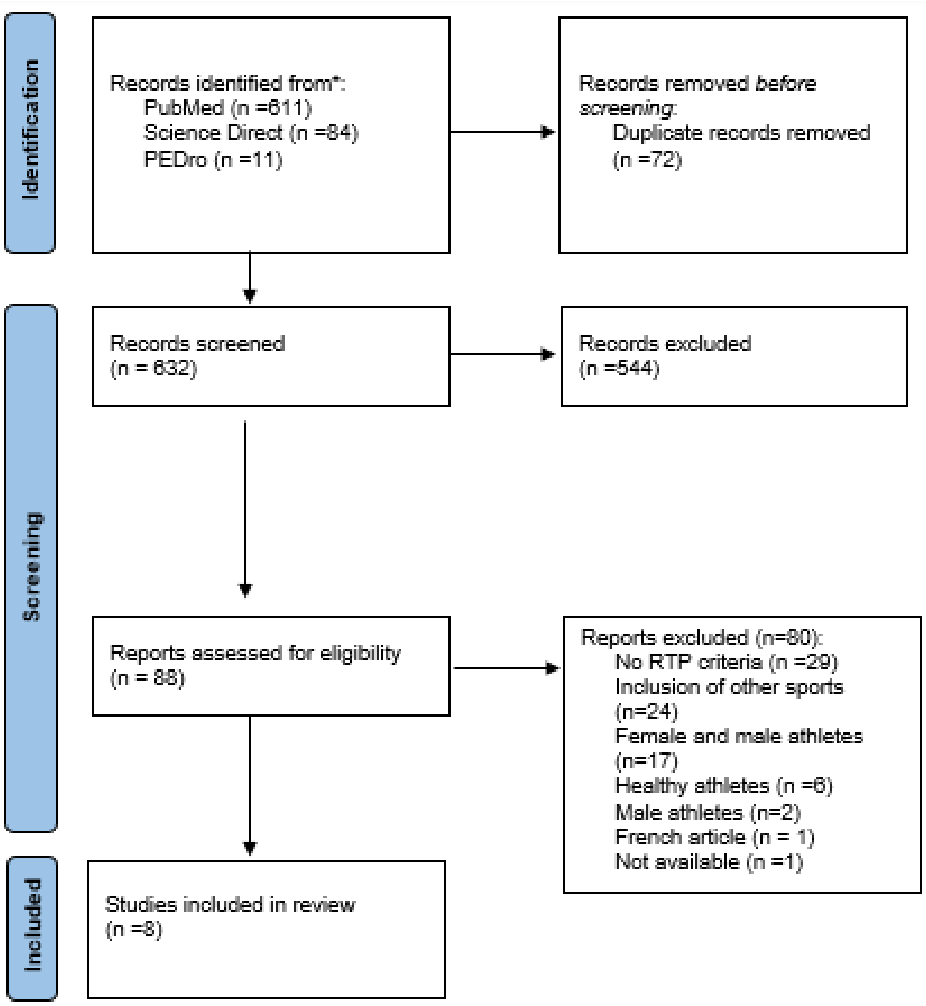

Figure 1: Flow diagram of study selection

3.1. Study and Sample Characteristics

Using the OCEBM LoE, this scoping review included one cross-sectional study, three cohort studies, and four case reports, this translates to 50% of the level of evidence 4 and 50% of the level of evidence 2. The total sample of the included studies amounts to 628 athletes, 432 of which had an ACL injury and ACL reconstruction, and 196 without an ACL injury belonging to the control groups. All athletes were soccer players, most being over 16 years old, with one exception being one of the case reports (age 12 years old).

Table 3: General characteristics of included studies

Nº	Author (year, country)	Sample data			Study type	Level of evidence
		Size		Mean age (years)		
1	Anne Fältström (2017, Sweden)	154	IG: 77 / CG: 77	IG:20,1 ± 2,3 / CG:19,5 ± 2,2[1]	Cross-sectional study	2
2	Mette K. Zebis (2017, Denmark)	1		21	Case report	4
3	Amelia J. H. Arundale (2018, Sweden)	117		19,9 ± 2,5	Cohort study	2
4	Jeffrey B. Taylor (2020, U.S.A)	1		12	Case report	4
5	Matt Taberner (2020, UK)	1		24	Case report	4
6	Anne Fältström (2021, Sweden)	236	IG: 117 / CG: 119	IG: 20 ± 2 / CG: 19 ± 3[2]	Cohort study	2
7	Anne Fältström (2021, Sweden)	117		20 ± 2	Cohort study	2
8	Josefine E. Naili (2023, Sweden)	1		18	Case report	4

Legend: IG-intervention group; CG- Control group;
[1] Group control: Same team, without ACLR
[2] Group control: Healthy knee players

3.2. Parameters and Test Outcomes

Six of the studies evaluated Hop performance, including a combination of the following tests: Six studies included single hop for distance test, three of them included the side hop test, two included the triple hop for distance test, the 5-jump test, or the single vertical hop test, and one study included the single crossover hop for distance test and the timed single leg 6m hop test.

Movement analyses were also a common parameter present in the studies, five of them used the drop vertical jump, four used the tuck jump and one used the countermovement jump. Three studies evaluated strength, two through isometric strength of flexion/extension of the knee and one through isokinetic evaluation of the same muscle groups.

Patient-reported outcome measures (PROM) of knee function and other parameters were also analyzed in three studies. Two used the International Knee Documentation Committee (IKDC) and one of these also used Anterior Cruciate Ligament -Quality of Life (ACL-QoL), ACL-RSI, Swedish Universities Scales of Personality (SPP), and Sport Multidimensional Perfectionism Scale (SMPS).

Two studies assess the external load, one adopting the GPS system and the other analyzing the total distance in rehabilitation sessions. Dynamic Balance was assessed in two studies using the Star Excursion Balance Test (SEBT). One study also included surgeon discharge and pain/swelling as parameters that should be considered for a safe RTP.

3.3. Criteria for RTP Discussion

On the hop test battery two studies used Limb Symmetry Index, LSI>90% for a successful test (Article 4 and 8), two used LSI >90% and <110% (Article 1 and 6), one used LSI >100% (Article 2) and one used different a reference for each test (LSI single hop for distance (> 102%), LSI side hop (> 97%), 5 jump test (> 916cm)) (Article 7). On strength evaluation, LSI > 90% was also used in two studies (Article 4 & 8) and the other one adopted the <5% asymmetry criteria between lower limbs (Article 5).

Movement analyses were assessed in different ways, for Countermovement Jump (CMJ) the study used the player's pre-injury data as reference values to RTP (Article 5). Tuck jump was analyzed through motion analysis software in one study (Article 7) and in the other three, the selected criteria was less than 6 flawed technique (Article 1, 3 and 6). As for the Drop Vertical Jump (DVJ), motion analysis software (Article 7), technique assessment by observation (Article 4), motion analysis (quality symmetry of takeoff, landing from box, knee motion, feet position at landing, weight displacement) (Article 3) and study sample values (Article 1) were used as references.

The SEBT had the same criteria in both studies where it was present, ≤0.04 m between limbs in anterior reach or composite score reach distance ≥94% of limb length (Articles 1 and 6). As for patient-reported outcomes, only one study presents values for one of the questionnaires (ACL-RSI <5,8) (Article 7).

To determine external load as RTP criteria were used subjective criteria, including enough load of pitch training, higher training load than pre-injury, enough load of technical actions (Article 5) and total distance in treatment sessions (Article 4).

Table 4: Outcome measures of included studies

Nº	Author (year, country)	Parameters	Tests	Tests outcomes
1	Anne Fältström (2017, Sweden)	Patient-reported outcomes	IKDC	-
		Hop performance	Single hop for distance 5 jump test	Hop tests: LSI >90% and <110%
		Movement analyses	Tuck jump test	<6 flawed techniques
			Drop Vertical Jump test	Values based on study sample
		Dynamic Balance	Star Excursion Balance Test	≤0.04 m between limbs in anterior reach Composite score reach distance ≥94% of limb length
2	Mette K. Zebis (2017, Denmark)	Patient-reported outcomes	Self-reported knee function	-
		Hop performance	Single hop for distance, Triple hop for distance, Single vertical hop	LSI ≥100% in all tests
3	Amelia J. H. Arundale (2018, Sweden)	Movement analyses	Tuck jump test	<6 flawed techniques
			Drop Vertical Jump test	Quality symmetry on takeoff, Landing from box, Knee motion, Feet position at landing, Weight displacement
		Patient-reported outcomes	-	-
4	Jeffrey B. Taylor (2020, U.S.A)	Hop performance	Single hop for distance Timed single leg 6m hop Triple hop for distance 1 leg crossover hop for distance	LSI >90%
		Strength	Isokinetic hamstrings Isokinetic quadriceps	LSI >90%
		External loads	Total Distance	-
		Movement analyses	Drop Vertical Jump test	Quality assessed by observation

Table 4 (continuation)

5	Matt Taberner (2020, UK)	Strength	Isometric strength	<5% asymmetry in lower limb muscle
		External loads	GPS	Enough load of pitch training Higher training load than pre-injury Enough load of technical actions
		Movement analyses	Countermovement Jump	Player's pre-injury data
		Surgeon discharge	-	-
		Pain/ swelling	Observation	No pain or swelling
6	Anne Fältström (2021, Sweden)	Hop performance	Single hop for distance Side hop	LSI ≥90% and ≤110%
		Dynamic Balance	Star Excursion Balance Test	≤0.04 m between limbs in anterior reach Composite score reach distance ≥94% of limb length
		Movement analyses	Tuck jump	<6 flawed technique
			Drop Vertical Jump test	<6.5cm knee valgus motion <4.1cm in frontal plane pKAM < 91%
7	Anne Fältström (2021, Sweden)	Patient-reported outcomes	IKDC, ACL-QoL, ACL-RSI, SSP, SMPS	ACL-RSI (<5,8)
		Hop performance	Single hop for distance Side hop 5 jump test	LSI single hop for distance (> 102%) LSI side hop (> 97%) 5 jump test (> 916cm)
		Movement analyses	Tuck jump test Drop Vertical Jump test	Motion analysis software
8	Josefine E. Naili (2023, Sweden)	Hop performance	Single hop for distance Single vertical hop Side hop	LSI >90%
		Strength	Isometric peak knee extension/flexion	LSI >90%

Legend: IKDC- International Knee Documentation Committee; LSI- Limb Symmetry Index; ACL-QoL- Anterior Cruciate Ligament -Quality of Life; ACL-RSI- Anterior Cruciate Ligament - Return to Sport After Injury; SSP- Swedish Universities Scales of Personality; SMPS- Sport Multidimensional Perfectionism Scale

4. Discussion

Even though the reinjury rate, after ACL reconstruction (ACLR), is higher in female soccer players than in male soccer players, 25% in women (Webster, 2021) to 7,4% in men (Farinelli, 2023), the information available about female athletes is very limited. Some hypotheses about the reason for this difference between sexes can be raised. A bigger dynamic knee valgus at landing, a higher Q angle, or a deficit in muscle strength can be associated with functional deficits in female athletes and lead to ACL injury (Della Villa, 2020) & Calvo Fernández, 2022 & Zago, 2021 & Zebis, 2015). The application of male study focus on female athletes can be a contributive factor for injury of this kind (Parsons, 2021 & Devana, 2022).

The literature says that the ACLR recovery process should be, at least, 9 months (Kaplan,2019), and it also says that most reinjures happen in the first two years after the reconstruction (Brinlee, 2022 & Badawy, 2022). Therefore, a rehabilitation process and consequent RTP should be done with criteria for a successful and free reinjury return to competition (Brinlee, 2022 & Almeida, 2018).

On the studies that were analyzed for this scoping review, the criteria that were used more times was the hop batterie of tests, present in 6 of the 8 studies. Hop test, according to one of the studies had a good test-retest reliability on soccer female players (Zebis, 2017). This battery of tests varied in composition (the single hop test was the one present in more studies). Although hop battery tests are present in most of the studies about return to play, the literature does not consider it a criteria that can be used by itself to determine RTP readiness. Like most studies with male athletes, it's also advised, in female athletes to use a batterie of tests that include several parameters (Bizzin, 2012 & Davies, 2017).

Lower limb strength and movement analyses were also used frequently as an RTP criterion. This kind of assessment is important due to the biomechanics associated with soccer and the higher number of movements that involve jumping, landing, and change of direction during a match or a practice session. The literature says that good levels of strength (Wang, 2023), are important to soccer players, even if most of the studies about this topic are about male players, also training age (the number of years that a player has been playing football) seems to be connected to a more symmetrical lower limb strength (Fousekis, 2010) and a lower risk of injury, this fact can be associated with a higher number of ACL injuries in younger athletes when compared with their older peers. Players with poor biomechanics have a higher risk of injury/reinjury, therefore, to prevent reinjury during the RTP process is advised to do movement analyses to assess the quality of athletes' movement and reduce the risk factors identified during this evaluation process. (Della Villa, 2022)

To evaluate hop performance, some studies used the LSI>90%. Using this criteria can bring another problem, LSI>90% does not take into account the decrease in performance of the uninjured limb during the recovery process due to the lower workload that the athletes endure when they are injured. Therefore, three of the studies used LSI >90% and <110%, to decrease the difference between limbs. One of the case reports uses the player's pre-injury data for reference values, this, when available, can be a big advantage to the recovery process and be very useful to RTP decisions because the decision-makers have access to pre-injury levels of performance, which can more easily be established as goals.

As for movement analyses, it can be considered more of a qualitative criteria. Most of the time it involves the subjective evaluation of the evaluator, making it harder to be reproduced by others because different therapists can have different perceptions of error or flaws in a movement analysis. A solution for this problem can be recording the tests for posterior analysis if necessary.

Workload is the less used criteria in the selected studies, maybe due to difficulty to access GPS equipment, since it is a more recent and expensive technology, but this parameter can be an interesting way of controlling the players' progression during the rehabilitation process and after the RTP. In the case reports where it is used the reference values are the athlete pre-injury data. Workload includes exposition pitch time and the number of technical actions, this can be very easily transferred to the pitch context when pre-injure data of the player is available. As a collective sport, that involves specific movements, the players, after the rehabilitation process, need to readapt to team playing, and that can only be done outside the clinical setting and onto the field. This adaptation should be gradual because an abrupt rise in workload, in soccer players, is associated with lower limb injury (Taylor, 2020), therefore the control of this criteria should be considered when assessing RTP, to a better adaptation to the team context.

Self-report questionnaires also show a lower quantity of information for female soccer players, nevertheless, the questionnaires present in these studies can be helpful to access red flags regarding players' mental condition and the level of confidence in RTP (Gomez-Espejo, 2022). Since a lower level of confidence and fear of movement are associated with reinjury, using this kind of questionnaire can help identify psychological barriers that can delay the player's return to competition (Badawy, 2022). A mix of physical and mental readiness should be the goal of the rehabilitation process (Badawy, 2022 & Brinlee, 2022). For this, it is advised that the decision-making process should be conducted by a multidisciplinary team, that also includes the player, making sure that the goals are aligned for everyone involved in the process.

Time alone, symmetry on strength and power and even the hop batterie can't be used as isolated RTP criteria (Fältström, 2021 & Taylor, 2020) because alone they do not necessarily translate to a good sports adaptation. It can be concluded that battery tests that include several parameters are the best way of assessing RTP readiness and this fact comes in agreement with the prior male-based studies (Bizzin, 2012 & Davies, 2017). The exact tests that should be in this battery have not yet been defined for this population, and it is pertinent to do so in the future due to the growing number of players in this specific sport.

5. Limitations and Strengths

This scoping review has some limitations, one of them is the low number of studies included, due to the lack of studies about the present topic. The lower level of evidence in the analyzed articles is also a factor to take into account, the studies with higher levels of evidence did not present a conclusive set of criteria for RTP in female athletes. Also, 50% of the studies are case reports, that showed a set of criteria but should be analyzed with caution due to their lower level of scientific evidence. These facts revert to the conclusion that more studies, with a higher level of evidence, should be done regarding this subject.

As for this scoping review's strengths, the fact that the sample it's of female soccer players only can be an important starting point for future studies that can focus on this growing population.

6. Conclusion

The rising number of female athletes in soccer, associated with a higher time of training and playing exposition can lead to an increased number of ACL injuries. Due to the longer time of recovery that's associated with this kind of injury, it is in athletes' and teams' best interest to make the rehabilitation and RTP process the fastest and most successful that it can be, minimizing the financial and sportive damage.

The literature on RTP criteria after an ACL injury, in female soccer players, is very limited. Isolated criteria are not recommended to make an RTP decision, and several parameters should be evaluated. The studies seem to agree that a batterie of tests is the best way of assessing the players' readiness to return to play, but the tests that should be included are not yet defined. Therefore, more studies with this population are required for further conclusions.

7. Declaration of competing interest

The author declares that there is no conflict of interest regarding this paper.

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Appendix 1: Articles included in this Scoping Review

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