Bachelor's project

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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ACL injury rate among soccer athletes: The effect of training interventions

Bachelor's project in Human Movement Science
Supervisor: Tonje Pedersen Ludvigsen
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Abstract

Background: Injuries among soccer athletes are common, and anterior cruciate ligament (ACL) injuries are one of the most prevalent. The aim of this thesis is therefore to investigate if training interventions, with the purpose of reducing injury, will reduce the ACL injury rate among soccer athletes. **Method:** The literature was retrieved through the databases PubMed and SPORTSDiscus. The eight articles included had to be randomized controlled trials (RCT) and the study population had to be soccer players. **Result:** A total of 11 228 soccer athletes were included to investigate the effect of prevention training programs (PTP) on ACL injury rate. Six of the articles show positive effects of PTP, while one shows little to no effect. The last study found a negative effect. **Conclusion:** Several factors need to be considered when implementing a prevention training program, and it is unknown what the optimal duration and content of such programs are. However, based on the results of the included studies, there is reason to conclude that a prevention training program can have a positive effect in reducing ACL injury incidence among soccer athletes.

Abstrakt

Bakgrunn: De siste årene har forekomst av skade økt, og èn hyppig fotballrelatert skade er anterior cruciate ligament-skade (ACL-skade). Hensikten med denne oppgaven er derfor å undersøke om treningsintervensjoner, med formålet å redusere risiko for skade, har en effekt på insidens av ACL-skader hos fotballspillere. **Metode:** Det ble foretatt et litteratursøk i PubMed og SPORTDiscus. De åtte inkluderte artiklene måtte være randomiserte kontrollerte studier (RCT), og utvalget måtte være fotballspillere. **Resultat:** 11 228 fotballspillere ble inkludert i oppgaven for å undersøke effekten treningsintervensjon vil ha på insidens av ACL-skade. Seks av studiene fant en positiv effekt av å implementere treningsprogrammet, og en fant lite til ingen effekt. Den siste studien fant en negativ effekt. **Konklusjon:** Det er en rekke faktorer som må tas hensyn til når man implementerer et forebyggende treningsprogram, og det er usikkert hva den optimale varigheten og innholdet i et slikt program er. Basert på de åtte studiene er det likevel grunn til å konkludere at forebyggende treningsprogram kan ha en positiv effekt i å redusere forekomsten av ACL-skader blant fotballspillere.

Keywords: Soccer, Anterior cruciate ligament injury, prevention program

1. Introduction

In recent years, sports-related injuries have increased (Bahr and Krosshaug, 2005) simultaneously with growing participation in sports (Stojanovic and Ostojic, 2012, p. 224). Injuries can cause life-changing limitations for competing athletes that can lead to prolonged absence from sport (Bahr and Krosshaug, 2005), and may reduce their future quality of life. Some sports, like soccer, basketball and handball have a particularly high injury rate (Stojanovic and Ostojic, 2012), and another study investigating sports-related injuries found that soccer accounted for 37% of all the reported injuries (Barengo et al., 2014). Soccer is considered one of the biggest and most popular sports in the world (Grooms et al., 2013). At the Fédération Internationale de football Association (FIFA) close to 270 million athletes are registered (Barengo et al., 2014), and the number are continuing to increase in professional, semi-professional and amateur athletes (Alentorn-Geli et al., 2009; Stojanovic and Ostojic, 2012). Soccer comes with multiple benefits regarding metabolic, cardiovascular and musculoskeletal health (Barengo et al., 2014). On the other hand, the participating athletes are at high risk for suffering injuries (Grooms et al., 2013). The sport contains elements like high tempo and quick direction changes, and injuries often happen because of the acceleration or deceleration of the body (Besier et al., 2001). Soccer-related injuries often occur in the lower extremities, more specifically the knee area (Grooms et al., 2013).

The knee is vulnerable, both because of its functional limitations, and the position of the joint. The knee is a hinge joint designed to carry the whole body weight (Hughston, 1962), and consists of four main stabilizing ligaments. One of the ligaments is the anterior cruciate ligament (ACL) that contributes to minimize tension across the joint (Stojanovic and Ostojic, 2012, p. 224). The ACL is a critical part of the knee that attaches the femur and tibia bone (Silvers and Mandelbaum, 2007) as illustrated in figure 1.1. There are over 250 000 ACL injuries annually in the United States (Silvers and Mandelbaum, 2007), and an injury in the ACL often comes with months of rehabilitation, surgeries, high expenses and increased risk of developing arthritis (Alentorn-Geli et al., 2009). The ACL can suffer an injury when an external force is applied that is greater than what the limb can handle (Contact injuries), like collisions and tackles. Regardless, the vast majority of ACL injuries happen through a non-contact mechanism (Besier et al., 2001), without external force being applied to the joint. This is due to the increased load on the ligaments during movements such as sidestepping and crossover cutting maneuvers (Besier et al., 2001), like jumping and landing with knee

extended, rapid direction changes and malalignment of the knee during landing (Alentorn-Geli et al., 2009).

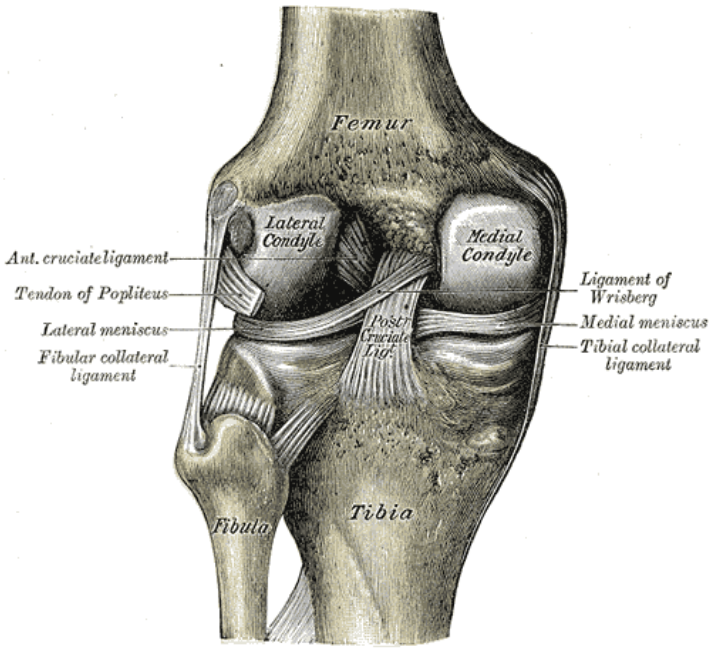

Figure 1.1. Interior ligaments in the left knee-joint shown from behind (Gray, n.d.).

An ACL injury can be caused by both extrinsic and intrinsic factors (Murphy et al., 2003). Examples of extrinsic factors are artificial turf and skill level, as well as coach feedback and technique. Some possible intrinsic factors include the tibia twisting internally in regard to the femur (Meyer and Haut, 2008), former injuries, flexibility, gender and age (Murphy et al., 2003). A former study investigated the impact the knee joint was exposed to during dynamic cutting tasks. They found that the combination between internal or external rotation, and additionally large varus or valgus increase, is related to increased risk of ACL injury (Besier et al., 2001). Regardless of age, gender and soccer abilities, there is no indication that the injury trend will stop anytime soon. It is therefore crucial to address the problem (Siegel et al., 2012).

The key to minimizing sports-related injuries in team sports in general is a prevention training program (PTP), which has shown an effect on ankle sprains in young adult volleyball athletes (Bahr et al., 1997). Former research also found that a structured warm up program could improve knee and ankle control in youth handball players, and reduce the incidence of

lower extremity injuries (Garrick and Requa, 2005). Another study found that interventions can be resourceful to reduce ACL injury incidence as well (Alentorn-Geli et al., 2009), and as a result it has sparked interest in researching injury prevention for soccer athletes. Therefore, the aim of this thesis is to investigate if training interventions, aimed to reduce the risk of ACL injuries, has an effect on the incidence rate of ACL injuries among soccer athletes.

2. Method

The research strategy used in this thesis was the PICO (Patient, Intervention, Comparison and Outcome) method (Helsebiblioteket, 2016). The medicine database PubMed, and the sports and human movement science database SPORTSDiscus were used for the literature search. The keywords used for the literature searches were “Anterior cruciate ligament”, “soccer or football” and “prevention”, resulting in 266 articles in PubMed and 183 in SPORTSDiscus. To fit the inclusion criteria, filters were used to only include English written studies and RCTs. In addition a filter in SPORTSDiscus was applied to ensure that the studies were peer reviewed. The literature search provided a total of 27 articles in PubMed and nine in SPOTSDiscus, whereas five articles were found in both databases, making it a total of 31 articles. After screening the titles and abstracts, 23 of the articles got excluded. The exclusion criteria were 1) articles that only consisted of American or Australian football, not including soccer, 2) if the study did not show the incidence rate or risk of ACL injury, 3) if the study did not contain all the keywords, and 4) the article was not an RCT. One article was obtained from a meta-analysis found through the same literature search. Eight articles met the inclusion criteria and were therefore included in this study. The athletes included from the studies that played in the 1. or 2. divison, will further be addressed as semi-professionals.

3. Result

In this thesis, the eight RCTs included a total of 11 228 participants that were divided into control groups and intervention groups, shown in table 3.1. The participants were soccer players, both semi-professionals and amateurs, male and female, with a mean age of 16,9 (3,5±) years. The interventions were all based on short warm-up programs, while the control groups in five of the studies were asked to continue with their standard warm-up, and the rest did not give the control group any instructions. The primary findings from each study are summarized in table 3.2.

Table 3.1: The characteristics of the studies

Authors	*Participants post drop-outs(n)*	*Gender (F or M)*	*Age (Mean)*	*Amateur or semi-professional*	*Intervention*
Caraffa et al. (1996)	600 (C=300, I=300)	x	x	Amateur, semi-professional	Everyday for 30 days (minimum 20 min), then 20 min, 2-6 times a week, for 3 years. Stand on 1 leg for 2,5 minutes, 4 times a day, on each leg.
Gilchrist et al. (2008)	1435 (C=852, I=583)	F	19.88	Semi-professional	30 min, 3 times per week, for 2.8 months. Contains basic stretch, strength, agility and plyometric training. Additionally, learning to avoid high-risk positions through watching a video.
LaBella et al. (2011)	855 (C=370, I=485)	F	16.21	Amateur	20 min, 3.3 times a week, for 3 months. Contains a combination of strength, agility, balance and plyometric drills, taught through the coaches.
Pryor et al. (2017)	89 (C=46, I=43)	M, F	11.5	Amateur	10-12 min, 3 times per week, for 8 months. Contains flexibility, body strength, agility, plyometrics and balance, taught through the coaches.
Silvers-Granelli et al. (2017)	1525 (C=850, I=675)	M	20.5	Semi-professional	15-20 min, 2-3 times per week, for the whole season. Contains strength, proprioception drills, agility and plyometric exercises.
Söderman et al. (2000)	140 (C=78, I=62)	F	20.45	Semi-professional	Everyday for 30 days, 10-15 min, then 3 times a week, for 6 months. On each leg 3 times, with 15 repetitions on each leg.
Steffen et al. (2008)	2020 (C=947, I=1073)	F	15.4	Amateur	15 min, 3 times per week, for 8 months. Contains agility, lower extremity strength, core stability and neuromuscular control.
Waldén et al. (2012)	4564 (C=2085, I=2479)	F	14.05	Amateur	15 min, 2 times per week, for 7 months. Consist of core stability and knee control, with strength exercises and jumping and landing technique.

n= Number, x= Missing data, C= Control group, I= Intervention group, F= Female, M=Male

Table 3.2: Numbers and percentages of ACL incidence rate in control and intervention groups. One study ([b]) is described with the number of participants classified as high risk to suffer an ACL injury.

Authors	*ACL injury control (n)*	*ACL injury intervention (n)*	*Statistical significance for IR between C and I (P-value)*
Caraffa et al. (1996)	70 (23.33%)	10 (3.33%)	<0.001
Gilchrist et al. (2008)	18 (2.11%)	7 (1.20%)	0.863
LaBella et al. (2011)	6 (0.79%)[a]	2 (0.27%)[a]	0.04
Pryor et al. (2017)	37 (80.43%)[b]	27 (62.79%)[b]	0.98
Silvers-Granelli et al. (2017)	16 (1.88%)	3 (0.44%)	0.021
Söderman et al. (2000)	1 (1.28%)	3 (4.84%)	>0.05
Steffen et al. (2008)	5 (0.53%)	4 (0.37%)	0.73
Waldén et al. (2012)	14 (0.67%)	7 (0.28%)	0.004

n= Number, C= Control group, I= Intervention group, IR= Injury rate, [a]=Soccer and basketball athletes, [b]=High risk classification

3.1 One component training

Two of the included studies investigated one component training programs: balance board training, on amateur and semi-professional soccer athletes (Caraffa et al., 1996; Söderman et al., 2000). Caraffa et al. (1996) researched the incidence of ACL injury and Söderman et al. (2000) investigated the incidence of lower extremity injuries, with ACL injury as a secondary outcome. In Caraffa et al. (1996) the intervention consisted of 5 phases with the same exercise performed on different surfaces and balance boards (Caraffa et al., 1996). In Söderman et al. (2000), all the intervened athletes got instructions from one of the authors and were given a balance board. The exercises were progressively harder, and the participants were instructed to stand on one leg with the knee slightly bent (Söderman et al., 2000).

The results from the first study showed that the athletes in the control group (n=300) had 60 more incidents of ACL injuries than the intervention group, respectively 70 and 10 ACL injuries (n=600). This indicates that each team in the control group would have 1,15 ACL injuries per team per season compared to 0,15 for the intervention group (P=0,001) (Caraffa et al., 1996). In the second study there were only one registered ACL injury in the control group and three in the intervention group (P= >0.05). In both groups, the injuries were mostly game related. They found no effect of balance board training for injury prevention in the lower extremities among female soccer athletes (Söderman et al., 2000).

3.2 Multi-component training

The remaining six studies included multi-component training interventions. Five of these studies provided data on ACL injury rate, whereas three of the studies had ACL injury rate as their primary outcome (Gilchrist et al., 2008; Silvers-Granelli et al., 2017; Waldén et al., 2012). The last study (Pryor et al., 2017) did not provide data on the incidence of ACL injuries, but instead calculated the risk of ACL injuries as their secondary outcome. All six studies were time efficient, dynamic interventions that could be performed on the soccer field without any special equipment. Further, two of the included studies had different progression levels in their intervention programs (Pryor et al., 2017; Waldén et al., 2012).

All six studies found more cases of ACL injuries in the control group compared to the intervention group. One study found two incidences of non-contact ACL injuries for the intervened athletes, and 10 in the control group (P=0,066), while the remaining injuries were contact ACL injuries (Gilchrist et al., 2008). LaBella et al. (2011), registered six cases of ACL injuries in the control group and two cases in the intervention group (P=<0,04). The results also showed that the teams using the prevention program the most, had a lower rate of acute onset lower extremity injury incidences. They did not differentiate between basketball and soccer when presenting the results (LaBella et al., 2011). In Pryor et al. (2017) the risk got calculated with LESS scores by how their movements differentiated from the ideal way of moving to prevent injuries. In the second period both the control and intervention groups received a PTP, the data is therefore collected prior to the second period. They found that >80% in the control group and >62% in the intervention group were categorized at “high risk”. Lastly, Pryor et al. (2017) found that the players who had previously done PTP were more likely to improve. A fourth study found 10 non-contact ACL injuries (1,5%) in the control group versus six (0,09%) in the intervention group (Silvers-Granelli et al., 2017). There were also more cases of ACL injuries on artificial turf in the control group (1,35%, 9/10) compared to the intervention group (0,35%, 1/10). In Steffen et al. (2008) there were five ACL injuries in the control group, and four in the intervention group, and the difference was not considered statistically significant (P= 0,73). During the game season, some of the teams in the study performed the program fewer times then they were assigned to do. There were 14 out of 58 intervention teams that completed more than 20 prevention training sessions (Steffen et al., 2008). After analysis of the adjusted subgroup in the study by Waldèn et al. (2012), the results showed an 83% reduction of ACL injury (P=0,004). Through further

analysis non-contact ACL injury showed the most reduction of incidence in the intervened athletes.

4. Discussion

Eight RCTs were included in this thesis to investigate the effect intervention programs have on incidence of ACL injuries among soccer athletes. In four studies the difference between the incidence rate in the control group compared to the intervention group was statistically significant (Caraffa et al., 1996; LaBella et al., 2011; Silvers-Granelli et al., 2017; Waldén et al., 2012), and the five remaining were not. Söderman et al. (2000) was the only study with more ACL injuries in the intervention group than in the control group, but these results were not statistically significant. Overall, the results show that an injury intervention can reduce the incidence of ACL injuries among soccer athletes.

4.1 Prevention programs- Duration, content and structure

The results of six studies showed an effect on reducing ACL injuries, regardless of the content of the programs. This indicates that there are more ways to reduce risk of ACL injuries. Due to the differences in PTPs there are however several factors that need to be addressed when analyzing the results. Three studies offered alternative exercises (Gilchrist et al., 2008; Pryor et al., 2017; Waldén et al., 2012), which can cause the PTP to vary among the athletes. The progression levels included in two of the studies (Pryor et al., 2017; Waldén et al., 2012) could potentially make the athletes perform different exercises from one another. It could affect the results if some of the participants were unable to proceed to the last progression level before the end of the study period. When investigating the three studies including alternative exercises, only one was statistically significant (Waldén et al., 2012), but it is unknown whether the alternative exercises actually impacted the ACL injury rate.

Two other studies, Caraffa et al. (1996) and Söderman et al. (2000), used the same preventive exercises as each other, but got opposite results. Caraffa et al. (1998) found a positive effect on incorporating balance board training both in preseason and during the competitive season on reducing ACL injuries. Söderman et al. (2000), on the other hand, found a higher ACL injury rate in the intervention group, and thus found no positive effect of implementing the

program. There are no obvious reasons for the contradicting results when they implemented similar interventions, but it might be because of the high drop-out rate (37%) in Söderman et al. (2000). Other influencing factors that may further explain the contradicting results could be gender, playing division and/or total exposure time on a balance board. In addition, it can be discussed whether the results of the different studies could have transferability to elite level athletes or not. The intervention of Silvers-Granelli et al. (2017) can be easily implemented and is time efficient, and may therefore be well suited for soccer players of different levels. This applies to several of the included studies as well, and strengthens external validity by having a PTP that can be performed by everyone, regardless of soccer abilities.

In regards to the duration of the interventions, a long-term and multi-seasonal PTP might be effective to provide a long-term safety for the athletes (Pryor et al., 2017). Caraffa et al. (1996) was the only study included that performed the program over multiple seasons, respectively three years. In addition, 15 interventions over the course of three months is considered to be too few to reduce injury risk (Steffen et al., 2008). Only one included study had fewer than 20 intervention sessions, and only two studies had a duration period shorter than $\leq$ 3 months, respectively 2,8 months and 3 months. When comparing the results from the study with the longest duration period (Caraffa et al., 1996), and the one with shortest duration (Gilchrist et al., 2008), only the longest was statistically significant. This suggests that it does matter how long an intervention program is applied and that less than 3 months is too short to see a statistical significant reduction in ACL injury rate. ACL injury, especially non-contact ACL injury demands a high level of exposure (Gilchrist et al., 2008). Hence, a large number of both training exposure and longer duration will increase the number of ACL injuries in the control group, but also give a better indication of the effect of intervention programs for the intervened athletes (Gilchrist et al., 2008). This further strengthens the importance of the duration and frequency of an effective PTP.

4.2 Intrinsic and extrinsic factors

Former studies claim that female soccer athletes are more likely to suffer an ACL injury than male athletes (Stojanovic and Ostojic, 2012, p. 224). Therefore, it is possible that gender may play a crucial part in the incidence rate, which is also reflected in the results from the studies

included in this thesis. When looking at the gender division there are five female studies, one male study and one study with both male and female athletes. The results from the female studies have a gap between intervention and control groups that is slightly smaller in incidence rate. Considering female soccer players have a three to five times higher risk of suffering an ACL injury (Soligard et al., 2008), the results in this thesis may be misleading when compared to the general population. On the other hand, the studies that included male soccer players (Pryor et al., 2017; Silvers-Granelli et al., 2017) had similar tendencies for injury in the control groups as the studies with female athletes, but had a much larger gap between the injury rate in the control group and the intervention group. Pryor et al. (2017) had close to 20% difference in ACL injuries between the two groups, while all the female studies had >1%. This may indicate that male soccer players need a lower amount of interventions to have an effect compared to female athletes. Considering the few male studies that were included in this thesis, more research on this particular area is needed to conclude whether male athletes could need a lower amount of prevention training to reduce ACL injury rate. Former research also found that female soccer athletes have a higher number of risk factors, compared to their male counterparts (Alentorn-Geli et al., 2009). This means that single-component PTPs, such that were included in Caraffa et al. (1996) and Söderman et al. (2000), may not be an adequate amount of preventive training to reduce ACL injuries in female soccer athletes (Alentorn-Geli et al., 2009).

Multiple studies also looked at younger athletes and ACL injury rate. Previous research found that younger athletes participating in pivoting sports, like soccer, are more likely to suffer injuries on a general basis (Bahr and Krosshaug, 2005). When comparing the study with the youngest sample size (Pryor et al., 2017) with the one with the oldest (Silvers-Granelli et al., 2017), the previous research can seem to be true. Despite this, considering Pryor et al. (2017) only has data on calculated risk of ACL, it can weaken this comparison. Nevertheless, it gives an indication on young age and increased risk of ACL injury. Since both youth soccer players and female athletes are at higher risk for injuries (Bahr and Krosshaug, 2005), and over half the studies contain one or both of these factors, it lowers the external validity of the results.

On the other hand, another study suggests that incidence of soccer injuries tended to increase parallel with age, among athletes older than 15 years (Barengo et al., 2014). This is not reflected in this thesis and might be a result of the study population having a mean age of

16,9 years, which is just above the lower limit (15 years). It is still a possibility that increased age can be a risk factor, but further investigation with more studies including older study populations is needed. The highest mean age in this thesis is 20,5 years old (Silvers-Granelli et al., 2017), therefore these results may not have external validity in regard to even older soccer athletes. However, it has internal validity because the age distribution in all of the included studies are limited to youth or young adults, ranging from 8- 21 years old.

Former research found that visual and verbal feedback could improve technique, which further could decrease the incidence of ACL injury among athletes (Stojanovic and Ostojic, 2012). Steffen et al. (2008) ensured to have a certified trainer to guide the athletes and provide experienced feedback, as well as ensuring proper technique. A possible downside with coaches compared to professional instructors who implement the program, is the performance and technical guidance. Some coaches that were older and less physically fit used fewer of the prescribed exercises, and potentially did not pass on the knowledge successfully (LaBella et al., 2011). To prevent this issue, they could bring an athlete to demonstrate the exercises, like they did in the study by Steffen et al. (2008). On the other side, Pryor et al. (2017) found that coaches trained to identify risk factors and implement the PTP can be just as effective as professionals. Regardless of who the feedback is given by, some risk factors that may be reduced due to verbal feedback is internal and external rotation, and large varus or valgus increase in the knee joint (Besier et al., 2001). It may improve the athlete`s technical performance and contribute to reducing the incidence rate of ACL injuries.

Another important extrinsic risk factor for ACL injuries is turf, and Silvers-Granelli et al. (2017) registered a statistically significant difference in ACL injuries on artificial turf between the groups (C=9, I=1, P=0,049). There were also more non-contact ACL injuries on artificial turf in the control group, respectively six incidents. Turf is a well known risk factor (Murphy et al., 2003), but little data on this factor was included in the studies. It is therefore challenging to evaluate the true effect of such extrinsic risk factors on ACL injury prevention.

4.3 Strengths and weaknesses in the included studies

A strength in this thesis is that all the studies that were included are RCTs, which prevents selection bias, and is the golden standard in research methods (Helsebiblioteket, 2016). To prevent contamination bias among the coaches in the study by LaBella et al. (2011), they

cluster randomized by schools, because one school had several teams. Silvers-Granelli et al. (2017) confirmed with each participant that they did not perform a PTP four months prior to their study to hinder participation bias.

A second strength is that the primary outcome of four studies were specific to ACL injury prevention (Caraffa et al., 1996; Gilchrist et al., 2008; Silvers-Granelli et al., 2017; Waldén et al., 2012). The remaining studies looked at ACL injury as a secondary outcome, and the PTP may therefore not be specifically designed to prevent ACL injuries. LaBella et al. (2011) also included basketball players in their study, so some of the incidents may not be related to soccer. Because there are no specific numbers for soccer and basketball it is challenging to compare these results to the studies that only included soccer players. Pryor et al. (2017) is the only study that does not include data on incidence of injury in their results, but rather categorized the athletes into high or low risk of injury. Compared to the other studies' incidence rate of ACL injury, the percentage of athletes within the high risk category is substantially high, both in the control group (80,43%) and the intervention group (62,79%). 11 of the people in the intervention group and six in the control group had improved their LESS score with >1, but still remained at high risk (p=0,001), which indicates that the PTP might have had a better effect than what the results indicated. It is also important to acknowledge that all of the high risk athletes will probably not suffer an ACL injury just by being categorized in the high risk group. This can limit the opportunity to compare this specific RCT to the others, because it lacks important data on the incidence of ACL injuries like the other studies included.

Thirdly, the sample size in six of the included studies are considered extensive. A former study claimed that a population of 180 athletes is too small to study the possible prevention of ACL injuries (Ekstrand, 1983), and all but two studies (Pryor et al., 2017; Söderman et al., 2000) have ≥600 participants. A larger study population will give statistically safer estimates and a possible higher internal validity (Pripp, 2018), which also strengthens the opportunity to generalize the findings from the included studies to the average athlete.

A limitation that occurred in rather few of the studies is low compliance to the program, which can explain the contradicting result of Steffen et al. (2008) compared to the other findings in this thesis. It was a large amount of break time from the prevention, due to

another warm up being used before matches. In addition, the summer break (7 weeks) was more or less free from soccer practices, and the results from Steffen et al. (2008) may therefore be insufficient in measuring the ACL injury rate when training frequency increases.

One confounding factor could be that multiple studies could not ensure that the control group did not perform preventive exercises during the study period. Steffen et al. (2008) and Waldèn et al. (2012) got information regarding the control groups' warm up, but they had no way of validating this information. The only study that mentions the content of the warm-up in the control group is Gilchrist et al. (2008), they observed players in the control group performing stretching exercises, which also was included in the intervention program. This might have played a role in their results not being statistically significant (Gilchrist et al., 2008). Three studies (Caraffa et al., 1996; Silvers-Granelli et al., 2017; Söderman et al., 2000) did not mention what the control group was instructed to do, which makes it uncertain what the intervention was compared to.

Another confounding factor could be if the athletes had former injuries. Several studies were aware of this and either excluded the ones with previous injury or noticed and registered the increased injury rates in the athletes with history of ACL injury. Surprisingly, Gilchrist et al. (2008) got less injuries within the previous injured athletes. This indicates that an PTP is also beneficial for athletes with former injuries.

Due to the factors mentioned above the results must be read with a critical view, considering the confounding factors. The studies included in this thesis only investigated amateur and semi-professional athletes, and the injury rate is higher on elite level, both because of higher injury exposure and training frequency (Caraffa et al., 1996). Consequently, more research is needed on ACL injury prevention among elite level soccer athletes, to increase the opportunity to generalize the findings to all soccer athletes.

5. Conclusion

The findings from the studies show that a prevention training program can have a positive effect on reducing ACL injury rate among soccer athletes. In the light of the findings, the cause of an ACL injury is likely multifactorial. It is therefore challenging to suggest an ideal PTP (duration, frequency and content), considering the injury has multiple risk factors.

However, longer periods of PTP did show a slightly more positive effect on reducing ACL injury incidence. Also, when incorporating one component balance board training, the ACL injury rate may be reduced. The injury rate seems to be even more reduced in the PTPs using multi-component training. To get an even greater understanding surrounding optimal prevention training for reducing ACL injuries among soccer athletes, more investigation is needed. Especially in regard to the complex interaction between risk factors, as well as including soccer athletes of all levels and genders.

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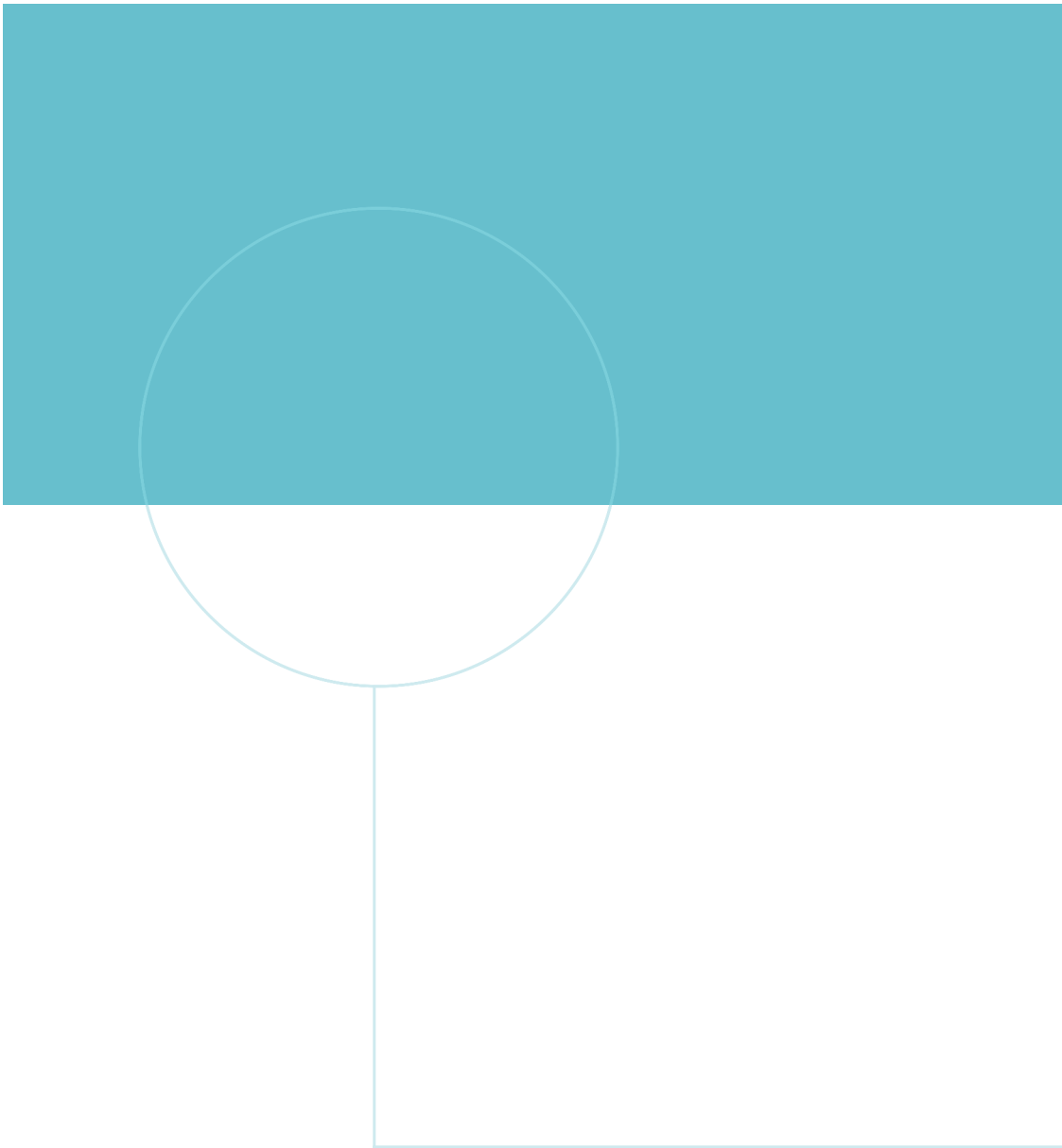

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