REVIEW ARTICLE

Prevention of ACL Injuries in Football

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A B S T R A C T

ACL injuries threaten the careers of many athletes and recreational participants in many sporting events. In football, the occurrence of ACL injury is considerably high. However, it was shown that prevention training programs could reduce the risk of this problem and therefore would be an advantages in terms of both avoidance of injury and being time and cost effective. The current review was aimed to address the specific components of both successful and unsuccessful prevention programs to provide evidence-based global guidelines for the reduction of ACL injury risk.

Keywords: *soccer, anterior cruciate ligament, sports medicine, rehabilitation*

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ملخص :

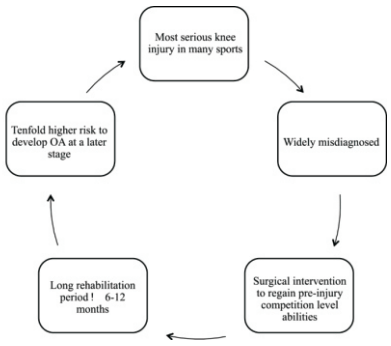
من المعروف أن إصابات الرباط الصليبي تهدد المسيرة الرياضية للعديد من الرياضيين المـ ـترفين والهواة على ـد ـواء. معدل هذه الإصابـات في رياضة كرة القدم على وجه التحديد في تزايد مستمر. مع ذلك فإن التمارين الوقائية قد تساعد في خفض هذه النسب بـ ـكل ملـ ـوظ، وـ ـد تكون وـ ـيلة مجديه لخفض معدلات التعرض للإصابة، إضافة إلى خفض التكاليف الطبية والعلاجية المرتبطة بإصابات الرباط الصليبي. لذلك الهدف من الدراسة الـ ـالية هو تـديم المكونات الناجـ ـة وغير الناجحة للبرامج الوقائية لتقديم الخصائص الأساسية للتمارين المساعدة في خفض معدلات إصابات الرباط الصليبي وذلك بناء على الأدلة العلمية المبنية على البراهين

INTRODUCTION

Football is recognized as the most popular sport around the globe (Junge et al., 2002). The number of active players in football was estimated to reach 200.000 professional and 200 million amateur participants (Junge et al., 2002) in 208 countries (FIFA, 2007). Not surprisingly, the occurrence of injuries in football is very common, with a greater chance of sustaining the injury in the Middle East than in North America (Harvard Medical International., 2007). This has been related both to the enormous popularity of this sporting event (Fauno and Jakobsen, 2006) and the resultant increasing number of participants (Hutchinson and Ireland, 1995). It is known that football injuries are among the highest rates of injuries in team sports (Engebretsen and Bahr, 2009), as they were estimated to account for at least half of the sports injuries in Europe (Maehlum and Daljord, 1984). A study on English footballers revealed that the risk of injuries in professional athletes is considerably high, with an occurrence ratio of 1000:1 among professional football players when compared to high-risk industrial occupations respectively (Drawer and Fuller, 2002). This has prompted the increase in evidence-based investigations in the field of sports medicine (Heidt et al., 2000). The number of studies in past decade uncovered an increment of 43% in injuries epidemiology, with even greater rise in clinical studies aiming at sports injury prevention (Engebretsen and Bahr, 2009). Studies on the assessment and evaluation of these injuries have shown a predominant (68% - 88%) occurrence in the lower extremity (Heidt et al., 2000). Furthermore, the highest rate of injuries (29%) of all injuries in football was shown to be a ligamentous nature (Ekstrand et al., 2003). The most common site for a football injury was found to be at the knee (20%) (Inklaar, 1994b). Football requires accelerating, decelerating, rapid change in direction and vigorous landing that subsequently compromise controlled movements of the knee and pose potential risks for the occurrence of an ACL injury (Fauno and Jakobsen, 2006).

The ACL is the primary ligament to stabilize the knee joint (Hewett, 2007). It prevents hyperextension and supports the stability of the knee during pivoting movements (MacAuley, 2007). The identification of the risk factors and development of appropriate prevention programs are essential for reducing the risk of ACL injury (Quatman and Hewett, 2009). ACL injuries are regarded as the most serious knee injury experienced by athletes in many sports, with concomitant detrimental consequences to athletes such as pain, disability and a tenfold higher risk of developing osteoarthritis at a later stage in life (Hewett et al., 2009a). Furthermore, there is evidence that ACL injuries are widely misdiagnosed (Bjordal et al., 1997) and contributes this further to the complexity of incurring this injury by athletes. The extent and severity of this injury noises the likelihood for the need for a surgical intervention to regain pre-injury competition abilities (Hewett et al., 2009a) and this usually brings forward the necessity for a considerable long rehabilitation period (6-12 months) to injured athletes (Brukner and Khan, 2006). It was therefore suggested that a rupture to the ACL in football could terminate the career of an athlete (Bjordal et al., 1997).

Figure1. A vicious cycle representation of the interrelated factors that contribute to the severity of ACL injuries. Adapted from (Hewett et al., 2009, Bjordal et al., 1997, Brukner and Khan, 2006). OA= Osteoarthritis.



The predominant occurrence of ACL injuries in football (76.5%) is in a non-contact situation (Rochcongar et al., 2009), indicating the importance of incorporating appropriate preventive measures. It has been postulated that structural, hormonal and neuromuscular factors are associated with the occurrence of ACL injuries (Hewett, 2000). However, the exact mechanism by which structural and hormonal factors contribute to the occurrence of injury remain to be elucidated (Koga et al., 2010). The higher incidence of the non-contact ACL injuries in team sports occur during cutting sidestep (McLean et al., 2005), landing and deceleration maneuvers (Boden et al., 2000). Injury during a sidestep pivoting maneuver occurs as athletes attempt to internally rotate while the foot is planted on the floor, aiming to change direction suddenly and abruptly during football games (Brukner and Khan, 2006). This when occurs knee in a valgus "knocked knee" position (Olsen et al., 2004). Subsequently, the knee incurs valgus collapse, and becomes inappropriately aligned by falling medial to the hip and foot (Quatman and Hewett, 2009). This alignment of knee was suggested to be the most susceptible position to incur ACL tear in sport (Ireland and 1996). Besides in football, the primary injury mechanism (34.5%) was found to be in a pivoting action (Rochcongar et al., 2009).

The mechanism of non-contact ACL injury during landing has been suggested to be created by the high posterior ground reaction produced by hard landing in sports (Yu et al., 2006). This causes the knee to flex, and an extension movement is generated to balance the knee by the quadriceps muscles (Yu et al., 2006). Consequently, an increased loading on the ACL is produced by the shear force at the proximal end of the tibia through the patellan tendon (DeMorat et al., 2004). In agreement with this motion it was shown that a powerful draw by the quadriceps with the knee is in the extension position could cause the ACL to rupture. These two mechanisms of injury are mainly associated with an incidence of an ACL injury in football (Rochcongar et al., 2009).

The increased risk for the occurrence of non-contact ACL injury in athletes could be associated with numerous factors such as being pushed or tackled during activities, unanticipated sudden change in direction and succumbing to lose their balance during match play and inadequate muscular strength and neuromuscular control (Boden et al., 2000, Teitz, 2001). Furthermore, fatigue and loss of concentration have also been ascribed to the high risk of incurring injury (Brukner and Khan, 2006). This could account for the multifactorial liability for sustaining an ACL injury. It is noteworthy that the presence of more than one of the risk factors was suggested to significantly noise the risk of sustaining an ACL injury when compared to the presence of a single risk factor (Hewett et al., 2009a). Therefore, the aim of this review is to analyze the current prevention programs and assess their perturbations. Furthermore, to evaluate the effective components they encompass based on the recent evidence-based findings to aid in the appropriate prescription and implementation of a beneficial program within a football organization.

Current prevention programs and components aimed at ACL injury reduction

The kinetic factors associated with ACL injuries are predominantly controlled by the central nervous system, as they control the patterns of motion (Garrett and Yu, 2007) and thus provides a rationale for the incorporation of neuromuscular training in the predominant ACL injury prevention programs (Hewett et al., 2006a). Recent studies indicated that neuromuscular training changes the muscle firing pattern, reduces the landing force and improves balance significantly (Hewett et al., 2005) and therefore are likely to reduce the incidence of ACL injuries (Hewett et al., 2009a). A recent study (Mandelbaum et al., 2005) introduced a prevention program for the under-14 to under-18 football players (n= 1041 first year; n= 844 second year). The intervention was adapted from the Prevent injury and Enhance Performance (PEP) program (SMOSMRF, 1999). The program introduced an educational visual aid to address high-risk maneuvers, and methods for appropriate execution of the prescribed exercises. In addition, the program consisted of warm-up, stretching, core strength, plyometric and agility training. The intervention emphasized on biomechanical techniques such as appropriate deceleration and landing techniques. This was aimed to address potential deficits in the strength and neuromuscular control of the muscles that stabilize the knee. The study reported an 88% and 74% reduction in the incidence of ACL injuries in the first and second year of the intervention respectively. Nonetheless, the study displayed limitations by the chosen non-randomized design. A similar randomized prevention protocol was subsequently implemented, and the effectiveness of this intervention corroborated the previous findings with significant reductions (70%) in the occurrence of ACL ruptures in collegiate football players significant reductions.

It was observed, based on the results of a meta-analysis of six neuromuscular interventions, that five of these provided some level of lower extremity injury risk reduction. This was evident by the overall number of ACL injury occurrences of ACL injuries in the prevention groups (29) when compared to the control groups (110) (Hewett et al., 2006a). A closer appraisal of the specific components of a successful prevention regime suggests that the incorporation of high-intensity plyometric training has shown to be an integral component in the ACL prevention programs. This was supported by the findings of the meta-analysis, which reported that the interventions that included plyometric training reduced ACL risk (Hewett et al., 2006a) and that studies that have failed to significantly reduce ACL injury risk were shown to neglect plyometric training (Heidt et al., 2000, Soderman et al., 2000, Irmischer et al., 2004).

Table1. Table of the successful and unsuccessful ACL prevention programs. FB=football, VB= Volleyball, BB= Basketball.

Author	Population	Duration	Protocol components	Outcome	Remarks
Heidt et al. (2000)	Female football players 14-18 y/o (n=300)	7-week pre-season 3 days/week	Aerobic conditioning Plyometrics Sport cord drills Strength training Flexibility	No significant reductions in experimental group 2.4% vs. 3.1% reduction rate experimental vs. control	- Non-randomised study - 7 weeks not sufficient to elicit NM reeducation
Söderman et al. (2000)	Swedish 2nd & 3rd division football players (n=221)	1 season 10-15 minutes with training	Balance board training	No reduction 80% ACL injuries in intervention group	-
Irmisher et al. (2004)	High school FB, VB, BB (n=1439)	9 weeks 3 post-training sessions/week 15 minutes/session	Strength training	No reduction	- 3 ACL in intervention group - 3 ACL in control group
Mandelbaum et al. (2005)	Football players 14-18 y/o (n=1041) 1st year (n=844) 2nd year	2 years Substitute warm-up	PEP Progtamme	Significant reduction 1st year = 88% 2nd year = 74%	- Emphasis on biomechanical technique training
Gilchrist et al. (2008)	Collegiate football players (N=1435)	1 year 3 sessions/week	PEP Programme	Significant reduction 70% reduction	- Emphasis on biomechanical technique training

The movement biomechanics and technique education has been shown to be a significant component in successful intervention programs (Mandelbaum et al., 2005, Gilchrist et al., 2008). In strong support of this, a positive correlation between appropriate jumping techniques and movement education and the reduction of ACL injury risk has been observed (Hewett et al., 2006a). Moreover, the non-effective studies have been shown to neglect biofeedback technique training. Although the efficacy of core strength and stability exercises remain equivocal (Hewett et al., 2009a), there is evidence that inadequate core neuromuscular control may compromise dynamic knee control, and therefore contribute in the risk of sustaining ACL injuries (Zazulak et al., 2007). This was suggested to be associated to deficits in neuromuscular control of the trunk that consequently stress the ACL and lead to injury (Hewett et al., 2005). These findings indicate that an inclusion of core strength training could contribute in the development of an optimal intervention plan. In support of this notion, it is apparent that successful prevention programs appear to include strength training (Mandelbaum et al., 2005, Gilchrist et al., 2008). Finally, with regards to balance training, the implementation this component alone was shown not to yield reductions in the ACL injury rate (Soderman et al., 2000) as apposed to the integration of balance board training within a comprehensive prevention program (Hewett et al., 1999) that may aid in injury reduction rates.

DISCUSSION

It has been shown that injury prevention interventions appear to present sufficient evidence in support of their efficacy in the reduction of sports injuries incidences (Junge et al., 2002). Indeed, it has been postulated that a 75% reduction in the risk of injury could be achieved by the adoption of an appropriate injury prevention program during the annual schedule for football organizations (Ekstrand et al., 2003). However, the bridging between theory and practice remains nominal. This is evident by the lack of awareness towards injury prevention plans at a professional level (Hawkins and Fuller, 1998), notwithstanding that the larger number of participants in football are considered to be amateur players. Accordingly, they are predisposed to be less informed with respect to injury prevention measures (Junge et al., 2002) and could be more susceptible to incur injuries. This gives rise to the necessity for increased awareness concerning the appreciation and promotion with regards to the importance and benefits of including injury prevention programs within a training regime. It has been proposed that injury prevention interventions should be included as soon as players begin to play or train at an organized level (Junge et al., 2002). This concurs with findings that the existence of a previous injury is the most significant risk factor for sustaining a subsequent sports injury (Inklaar, 1994a).

The benefits of implementing injury prevention programs are numerous. The primary reason is to reduce the number of injuries and the degree of severity (Ekstrand et al., 2003). Thus, the athletes benefit through a greater well-being and health, while prolonging their sporting careers. In addition, injury prevention approaches could be used a motivational tool to elucidate the likelihood for success and attaining a team selection position for injury-free athletes (Engebretsen and Bahr, 2009). The sport and the health sectors acquire gains by this approach through the reduction in costs created by the high medical costs for injury management for athletes; where management of ACL injuries surgically of conservatively for a single athlete has been estimated to cost $17000 (Engebretsen and Bahr, 2009, Hewett et al., 2009a). The potential reduction in costs through the implementation of ACL prevention was estimated to eradicate 80% of the recent costs associated with ACL injuries annually (Hewett et al., 2007b).

The anterior cruciate ligament has been increasingly problematic for athletes in all levels, with risks associated to both physical and psychological detriments upon incurring this injury (Gilchrist et al., 2008). The findings from the previous studies aid in the determination of the successful and unsuccessful components of ACL prevention protocols. Furthermore, it indicates the development of ACL injury research, and the continuous efforts to aid in the reduction of the record numbers of ACL injury incidences (Bjordal et al., 1997).

The examination of the intervention programs that claim to reduce ACL injury risk provide a foundation for the development of optimal prevention methods. They provide valuable global guidelines for the potential reduction in the rate of incidence of the detrimental consequences of ACL injuries. The recent focus on neuromuscular training was rationalized as the likely factor for the increased risk for sustaining this injury (Hewett et al., 2007a). This was supported by the recent findings by that athletes who incur ACL injury land with apparent reduced knee control (Quatman and Hewett, 2009). Moreover, the role of inadequate neuromuscular trunk stability seems to augment the risk of sustaining an ACL injury (Hewett et al., 2009b). Collectively, the recent strong evidence that links decreased ACL injury risk with neuromuscular training suggests that the mechanisms related to the increased risk are neuromuscular in nature (Hewett et al., 2006b). The evidence from the literature indicated that the 4 integral components to be integrated in an effective prevention plan are high-intensity plyometrics, biofeedback technique education, balance and strength training. This is evident by the significant reductions in injury rate observed from the most effective prevention programs (Hewett et al., 1999, Mandelbaum et al., 2005, Gilchrist et al., 2008).

The implementation of intervention program sessions are suggested to be effective when applied more than one session per week. Furthermore, an implementation of a minimum six-week pre-season prevention protocol is indicated to yield sufficient injury reductions at the first half of the season (Hewett et al., 2009a). This period is suggested to elicit adaptations and improvements, and thereby reduce impact forces and knee abduction moments (Myer et al., 2005). This was corroborated by recent findings that reported that the application of a prevention program only during the season induces feasible effects at the latter stages of the season (Gilchrist et al., 2008).

CONCLUSIONS

In conclusion, the significant reductions in ACL injury occurrences in the successful prevention programs appear to be associated with the combination of the aforementioned components (i.e. plyometrics, biofeedback technique education, balance and strength training), as they seem to produce plausible effects via an additive mechanism (Hewett et al., 2007a). Nonetheless, it remains unclear which component provides the most efficacious results, or whether the amalgamation of these components is ascribed for optimal prevention outcomes (Silvers, 2007). Although the current knowledge in this area suggests that appropriate applications of prevention programs may elicit profound benefits on both athletes and sporting organizations, continuous research to investigate the risk factors and injury mechanism(s) remains critical to provide a comprehensive understanding of ACL injuries and further develop the current preventative measures.

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