

Summary

Findings from efficacy studies have shown decreased in ACL injury rates in (predominantly female) athletes participating in prevention programs. Given the inherent higher ACL injury risk for females, the majority of intervention studies, have focused on female athletes. Subsequently, the content of exercises in ACL prevention programs is directed to target the modifiable ACL injury risk factors for female athletes. The literature is generally scarce regarding the efficacy of prevention programs to reduce ACL injuries in male athletes. In general, reduction of ACL injury rates seem to be limited to (young) female athletes and male athletes playing at low level of sports. Typically, ACL injury prevention programs entail a combination of plyometrics, strength training, agility and balance exercises. A problem is that improvements of movement patterns are not sustained over time. The reason may be related to the type of instructions given during training. Encouraging athletes to consciously control knee movements during exercises may not be optimal for the acquisition of complex motor skills. In the motor learning domain, these type of instructions are defined as an internal attentional focus. An internal focus, on one's own movements results in a more conscious type of control that may hamper motor learning. It has been established in numerous studies that an external focus of attention facilitates motor learning more effectively due to the utilization of automatic motor control. Subsequently, the athlete has more recourses available to anticipate on situations on the field and take appropriate feed forward directed actions. The purpose of this manuscript was to present methods to optimize motor skill acquisition of athletes and elaborate on athletes' behavior.

Keywords

ACL injuries – Prevention – Motor learning – Attentional focus

REVIEW / SPECIAL ISSUE

Using principles of motor learning to enhance ACL injury prevention programs

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Introduction

Team-based exercise training has become a popular method for delivering anterior cruciate ligament (ACL) injury prevention programs in various sports [32]. Systematic reviews of efficacy studies have demonstrated that ACL injury prevention programs reduce injury rates and, as such, provide an evidence base for implementation [4,20,25,43,45]. Even though the benefits of such programs have been demonstrated in efficacy studies, they provide limited knowledge of real-world benefits [18]. The benefits of such programs

has largely been undertaken in efficacy studies involving highly controlled settings [18]. However there exists a gap between research and practice in the field of sports injury prevention and safety promotion [24]. The implementation in the real-world setting remains a major challenge [46]. This is often based on the assumption that a transition follows from successful efficacy research to effectiveness research under real-world conditions [21]. Although researchers may have sound biomedical evidence for a prevention training, this is in no way guarantee it will be successfully adopted [16]. For example, only 16.7% in UEFA and Norwegian professional football teams adhered to

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Anwendung von Prinzipien des motorischen Lernens zur Optimierung von VKB-Präventionsprogrammen

Zusammenfassung

Angesichts des höheren Risikos für VKB Verletzungen bei Frauen wurden die Übungen der entsprechenden Präventionsprogramme auf modifizierbare VKB-Verletzungsrisikofaktoren von weiblichen Athleten ausgerichtet. Wirksamkeitsstudien haben gezeigt, dass sie insbesondere bei jungen Sportlerinnen und auf niedrigem Sportniveau spielenden männlichen Athleten erfolgreich sein können. In der Regel beinhalten diese VKB-Präventionsprogramme eine Kombination aus plyometrischen Übungen, Krafttraining, Beweglichkeit und Balanceübungen. Noch ist nicht genau bekannt, welche Faktoren zu ihrer Effektivität beitragen. Auch etwaige erlernte Verbesserungen des Bewegungsmusters können nicht immer langfristig erhalten bleiben. Hierfür könnte die Art der Trainingsanweisungen verantwortlich sein, die darin bestehen, Kniebewegungen während den Übungen bewusst zu kontrollieren. In der motorischen Lerndomäne ist diese Art der Anweisung als interner Aufmerksamkeitsfokus definiert. Dies kann zu einer bewussteren Art der Kontrolle führen, die das motorische Lernen paradoxerweise behindern kann. In zahlreichen neueren Studien konnte nachgewiesen werden, dass ein externer Aufmerksamkeitsfokus das motorische Lernen durch den Einsatz der automatischen motorischen Steuerung effektiver gestalten kann. Nach dieser Theorie stünden dem Athleten mehr Möglichkeiten zur Verfügung, um Situationen auf dem Spielfeld voraussehen und geeignete antizipative Aktionen einleiten zu können. Der Zweck dieser Übersichtsarbeit besteht darin, Methoden zur Verbesserung der motorischen Lernfähigkeiten von Sportlern vorzustellen und das Verhalten der Sportler zu erläutern.

Schlüsselwörter

VKB-Verletzungen – Prävention – motorisches Lernen – Aufmerksamkeitsfokus

an evidence-based hamstring injury prevention program [7]. Only those prevention programs that are adopted by athletes, coaches, other intermediaries and sporting bodies will actually prevent injuries in the real-world [16]. High quality implementation planning can be achieved with a strategic, ecological approach based on a partnership between program developers (researchers) and program implementers (gatekeepers and end users) [16]. It has been recommended that researchers, practitioners and community end users collaborate early in the implementation planning process [16].

In light of the aforementioned, many challenges exist. Looking at effectiveness, ACL injury rates have not decreased over the last decades. To illustrate, an increase in the annual injury rate of ACL injuries per 1000 athlete-exposures for female football players from 0.13 (1990–2002) to 0.25 (2009–2014) has been reported in the National Collegiate Athletic Association (NCAA) [1,41]. In an update of 2004–2013 compared to 1988–2004, increases in the average annual number of ACL injuries were found for male and female players in basketball, ice hockey, field hockey, football and volleyball whilst a decrease has been noted for baseball and women's gymnastics [2].

Considering that ACL injury rates are still high may, in part, be attributed to the fact that not all available prevention strategies have been employed to their full potential (Table 1).

For example, a survey pertaining an injury prevention intervention, revealed that athletes complied well with the protocol, but coaches did not, especially at the middle school level [42]. In female athletes, about 70% of ACL injuries can be prevented, if an injury prevention is done for a total of more than 30 min per week during the in-season (preferably over multiple sessions)

[44]. Based on recent work by Haddon et al. intervention strategies against injury can be divided into two dimensions [48]. In regards to sports, in the first dimension, interventions can be targeted at the athlete, rules and regulations, sport equipment and the physical, socio-cultural and policy setting or context within which the sports injury occurs. The second dimension deals with the time frame in which an injury occurs, i.e. pre injury event, injury event and post injury event. The purpose of this manuscript was to present methods to optimize motor skill acquisition of athletes and elaborate on athletes' behavior (first domain) and pre injury event (second domain) in the context of ACL injury prevention [48].

The goal is that athletes acquire the ability to sustain optimal motor control while engaging in complex athletic environments, whilst minimizing their risk to sustain an ACL injury.

Target the athlete

In the following section we will present novel motor learning training methods that might improve ACL injury prevention strategies, addressing athletes' behavior in a pre injury event.

Attentional focus

While the efficacy of ACL injury prevention programs has been demonstrated (mainly in handball and football), the ideal combination of training components within these programs remains unclear [20]. Typically, ACL injury prevention programs entail a combination of plyometrics, strength training, agility and balance exercises [4,20,45]. A problem of the current ACL injury prevention programs is that they appear to result in only temporary improvements in movement patterns that are associated with

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