11 Prevention Strategies in Traumatic and Overuse Injuries

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11.1 Introduction

Injury reduction strategies consist of a series of possible interventions (mainly based on the application of exercise programs) that have the potential to reduce the likelihood of serious injuries to the lower limb.

The prevention protocols that have been developed (mix of different exercises that can be done as a structured warm-up) show good effectiveness in reducing match and training injuries in most sports in which they have been implemented correctly. A main barrier for real world effectiveness of these programs has always been the implementation in day-by-day team and/or individual practice.

As a sports community (not limiting to Sport Medicine practitioners) we have the responsibility to ensure a sustainable practice (with performance/injury prevention balance) for our athletes (in both primary prevention and secondary prevention setting) from youth through to elite adult sport.

Families, managers and all the major stakeholders of the player's life should be informed about the best practice to protect the players' health through his/her development, especially in the key pre-adolescent and adolescent phases, reducing the likelihood of a life-changing injury, like an anterior cruciate ligament (ACL) injury.

With the support of unconventional figures for the medical area, like families, parent's organizations, managers and so on, the medical staff in a team environment nowadays has the responsibility to engage preventative measures and education in the day-by-day practice.

The aim of this chapter is to present the current evidence-based approach on prevention strategies for acute and overuse injuries of the lower limb in a sport setting. General recommendations will be presented in an easy way to facilitate the dissemination of basic injury prevention (reduction) principles.

11.2 Prevention Principles

The principles related to prevention (reduction) of overuse and acute injuries are easy to comprehend but challenging to be applied correctly. Here there is a list of key principles you can consider in the day-by-day sports practice.

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11.2.1 Prevention Can Start Early in the Athlete's Life

There is no reason to focus injury prevention only on elite adults; we should balance the sport specificity of the technical gesture with the general physical readiness to play from the very beginning within youth sports. The first reason to do that is to reduce the injury rate in youth sports (application of FIFA 11+ kids in players aged 7–13 years reduces the overall injury rate and severe injury risk by 50% and 74%, respectively). Secondly, the aim of this approach is to create a preventative culture within the team and on each single player. A young athlete well educated in injury prevention practices is more likely as an adult athlete to apply these practices. A correct preventative program increases the neuromuscular control of the player whilst strengthening key muscles and corrects movement patterns whilst optimizing performance.

11.2.2 Prevention is Based on a Mix of Exercises That Can Be Done as Warm Up: The So-Called Neuromuscular Training (NMT) Programs

The NMT programs (like the "FIFA 11+", Fig. 11.1) are simple exercise programs that should be integrated in the team practice. We suggest to simply integrate these exercises as the warm up during each training sessions to ensure the players use the program regularly. The "11+" program can be downloaded from www.fmarc.com, but many other NMT programs exists and are published in the literature (few examples are reported in Table 11.1).

11.2.3 The Correct Technique of Exercises Is Key to Enhancing Preventative Effects

The exercises which constitute the NMT program should be done with proper technique, avoiding risky positioning of body segments, such as knee valgus appearance (knee falling medially) or trunk and pelvic imbalances (trunk tilt or and pelvic drops or hikes). Suboptimal techniques are associated with increased joint (i.e. knee) overload and should be avoided when performing the specific exercises.

The complete manual for the "FIFA 11+" can also be downloaded from www.fmarc.com and a complete read is recommended to apply correctly this program.

11.2.4 Prevention Works Only If the Correct Dose Is Applied (Optimal $\geq$ 2/Week)

It is demonstrated that the compliance to the injury prevention program that can be simplified as the number of sessions per week, is correlated to the effectiveness of the program. In other words, the more you do and the better it is. It seems that the preventative effect of NMT is higher when you complete more preventative sessions a week. Our suggestion is to apply such a program at least 2–3 times a week (with 3 being the optimal dose).

11.2.5 Additional Prevention Can Be Targeted on Specific Risk Factors

Beside general injury reduction programs, prevention of primary and secondary injuries may be targeted to specific risk factors a player may present compared to other peers. It can be the case that some of the players of a team should be exposed to additional volume and specificity of preventative measures based on a predisposition to a certain type of injury. Examples can be useful to explain this aspect.

The first example is a patient with a clinical history of a structural hamstring injury. His/her positive clinical history is correlated to a sevenfold increased risk of sustaining a hamstring injury if compared to the other players. This player will benefit to a greater extent with

Fig. 11.1 The FIFA 11+ is the classic example of NMT program

Table 11.1 Commonly used injury prevention programs that showed effectiveness in injury reduction

Injury prevention program	Available resources
FIFA 11+ (football)	http://fifamedicinediploma.com/lessons/prevention-fifa-11/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2600961/ https://www.ncbi.nlm.nih.gov/pubmed/29209504
PEP (football)	https://www.youtube.com/watch?v=t_yz7yWLo5o http://la84.org/a-practical-guide-to-the-pep-program/ https://www.ncbi.nlm.nih.gov/pubmed/15888716 http://ajs.sagepub.com/content/36/8/1476.full.pdf+html http://ajs.sagepub.com/content/33/7/1003.full.pdf+html
Sportsmetrics (football, volleyball and basket)	http://sportsmetrics.org/ https://www.ncbi.nlm.nih.gov/pubmed/10569353 http://ajs.sagepub.com/content/27/6/699.full.pdf+html
Knäkontroll (football and handball)	App available on Apple or Android platforms: https://itunes.apple.com/se/app/knakontroll/id573826071?mt=8 https://play.google.com/store/apps/details?id=se.rf.sisu&hl=en https://www.ncbi.nlm.nih.gov/pubmed/22556050 http://www.bmj.com/content/344/bmj.e3042.full.pdf+html

Commonly used injury prevention programs with links to available online resources to guide a practical application and correct knowledge dissemination. *FIFA* Fédération Internationale de Football Association, *PEP* prevent and enhance performance program

specific hamstring prevention exercises (e.g. eccentric strengthening of the posterior kinetic chain using the Nordic Hamstring Exercise) compared to other athletes, which should be highlighted. The recommendation here is to continue to apply the general NMT program adding more focus on injury specific prevention measures.

The second example regards the ACL injury reduction strategies. A female footballer with a positive family history of non-contact ACL injury (brother and mother) undergoes a pre-season assessment including a measurement of movement quality that showed an excessive dynamic knee valgus loading (knee moving medially and caving in) at a jumping task, a well-known potential risk factor for ACL injury. In this case, there is clearly a possible predisposition to ACL injury, based on the family history and the movement assessment. This player should continue to perform general NMT programs but should also complete a targeted NMT based on her risk profile (excessive dynamic knee valgus), which should include targeted corrective muscle strengthening of the hip muscles, alongside movement re-training employing specific feedback techniques to eradicate the knee valgus loading. Research showed that "at risk" individuals benefit to a greater extent from the application of NMT programs. Again, this aspect should be highlighted.

11.2.6 Train Smarter and Harder

A relatively new tool in injury prevention (reduction) strategies is to consider the player's loads during training and matches. Athlete's injury risk is increased when they perform higher workloads (training or matches) than they are used to. The key principle is to progressively develop the workloads, avoiding high spikes to achieve moderate to high workload capacity. In simple words if the player is used to having a consistent training load (e.g. training two-times per week and playing one match) then it is not wise to rapidly increase this training program double (e.g. training four times per week and playing one extra match) without progressively increasing this over time. Developing high "chronic" training loads is protective and can prevent a player been exposed to high training loads for which they are not prepared for. Of course, regular high training loads can increase the risk for certain injuries like stress related injuries, so managing the training schedules and allow appropriate rest and recovery is important.

What to do?

Given the overmentioned principles, what should you do in your daily approach starting from the very beginning of athlete's sport activity. In Table 11.2, there is a list of actions that the environment around the athlete should put in place to reduce the injury risk in sports.

Table 11.2 Practical suggestion to adopt an injury prevention (reduction) strategy for player and player's environment

Principle	Actions
Start early	Implement the use of FIFA 11+ Kids (or similar programs in non-footballers) from 7-year-old players up to 13 years old. Use it at least 2 times a week (the program duration is 15–20 min) Apply prevention to all the players **Do it** Link to the program: https://www.fifamedicinediploma.com/wp-content/uploads/2016/11/11_kids_poster.pdf Link to the manual: https://www.fifamedicinediploma.com/wp-content/uploads/cdn/fifa11plus_kids_booklet.pdf
NMT programs: mix of exercises	From pre-adolescent/adolescent players: choose a NMT program (i.e. FIFA 11+; PEP; etc.) with proven effectiveness in reducing injuries (see Table 11.1) Study it properly in term of application Integrate it as part of the standard team warm up. Use it at least 3 times/week Apply prevention to all the players **Do it**
Correct technique of exercises	Study very well the recommendations regarding the quality of the different NM exercises Perform the double leg and single exercises with frontal plane neutral hip (no significant adduction/intra-rotation), knee (no significant adduction) and ankle/foot (no pronation or excessive rotations) Avoid excessive knee valgus loading (knee moving medially and caving in) Avoid trunk tilt and or pelvic drops and hikes
Correct dose of NMT	Do the NMT programs regularly and consistently At least 2/3 times/week is the correct dose for this intervention Do not allow a different application (if you do so NMT is less effective)
Target additional prevention on some athletes	Consider the clinical and family history of the player In case of positive clinical history of **muscle injury** be very specific in adding injury-specific prevention on the risk factor In case of positive clinical or family history of **ACL injury** add more attention to ACL preventative measures In case you decide to do a preseason assessment of NM control, use validated tests (i.e. Tuck Jump assessment; link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4168972/pdf/nihms627257.pdf) In case you have (or decide to do) pre-season screening, use this information to target specific interventions (i.e. excessive knee valgus at jumping tasks > feedback techniques to reduce the dynamic knee valgus loading)
Train smartly	Consider using tools that allow you to control the player load during training (i.e. session rating of perceived exertion (sRPE) or GPS technology where possible and appropriate. Link to literature: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5673663/ If using GPS, decide a predetermined number of metrics (not too many) to control considering general volume metrics (i.e. distance in km) and high intensity metrics (i.e. acceleration/deceleration in m) Create a stable training for the players building a chronic workload Avoid increasing over 50% from one session to the next Avoid large increases in session frequency and match-play at one time

What to do practically in term of injury prevention (reduction) strategy. *FIFA* Fédération Internationale de Football Association, *PEP* prevent and enhance performance program, *NM* neuromuscular, *NMT* neuromuscular training, *ACL* anterior cruciate ligament

11.3 Which Results Can I Expect? General and Injury Specific Results

11.3.1 Overall Injury Risk

There is conclusive evidence about the effect of injury prevention (reduction) programs on the overall injury risk of athletes. NMT is the best preventive measure for sports injuries. Major clinical research studies published since 2008 have clearly indicated that, for example, the consistent implementation of the FIFA 11+ can lead to a 30/50% reduction in injuries. Teams that performed the FIFA 11+ regularly at least twice a week had 37% fewer training injuries and 29% fewer match injuries. Severe injuries were reduced by almost 50%, acute injuries by 32% and overuse injuries by 54%.

11.3.2 ACL Injury Risk

Several meta-analyses have been published on the effectiveness of NMT in preventing ACL injuries. Recent and conclusive evidence showed that there is an overall 50% reduction in the risk of ACL injuries in all athletes and a 67% reduction for non-contact ACL injuries in female athletes. Therefore, NMT can cut in half the overall risk of ACL injury in all athletes and reduce by two-third the ACL injury risk in female athletes. Given the severity of an ACL injury, that is commonly considered the nightmare for every athlete, these results are really important and encouraging. Part of ACL injuries are preventable.

11.3.3 Hamstring Injuries

Including the Nordic hamstring exercise in injury prevention programs could significantly reduce the rate of hamstring injuries across different sports and age groups in both women and men. Injury prevention programs that included the Nordic hamstring exercise showed a reduction in the overall injury risk by up to 51% when compared with usual training or other prevention programs. Given the high rate of muscle injuries generally observed in team sports, applying this exercise in detrimentally important.

11.3.4 Adductors Injuries

Including the Copenhagen adductor exercise program a part of the structured warm up program could further reduce injury incidence in athletes. Adductor strains are common in team sports and using the adductor strengthening program has been shown to reduce adductor injuries by 41% in semi-professional soccer players [1].

11.4 Targeted Preventative Training Based on a Specific Assessment: The Example of the ACL Injury Prevention Paradigm

On the side of general injury prevention, it is possible to target our intervention on specific risk factors. As an example of this paradigm, we can consider the targeted prevention of non-contact ACL injuries in young athletes. Research has demonstrated that there are specific movement patterns (ways of moving certain body parts) that can be linked to non-contact ACL injuries (either in video-analysis studies or prospective studies). These patterns may be assessed using for example a video-analysis of an athlete jumping (i.e. drop vertical jump, Tuck jump) or performing another movement task (i.e. side step cutting). For each movement error there is a specific intervention that should be carried out (Table 11.3).

Table 11.3 Neuromuscular imbalances and specific intervention for primary ACL injury prevention based on a movement quality assessment (Tuck Jump assessment)

Neuromuscular imbalance	Intervention
Excessive knee adduction with knee valgus appearance on the frontal plane (so-called Ligament dominance)	Train for proper technique (no valgus) with feedback training Functional strengthening of hip muscles (hip abductors)
Low knee flexion angle at landing with stiff landing (so-called Quadriceps dominance)	Progressive plyometric training (easy to advance) and strengthening of the posterior kinetic chain
Asymmetrical landing with favoured lower limb (so-called Leg dominance)	Train side-to-side symmetry
Trunk and pelvic imbalances (tilts) with inability to control the centre of mass (so-called Trunk dominance)	Core stability and perturbation training with functional strengthening of trunk muscles

Underlying neuromuscular imbalances and specific interventions based on a Jump assessment in the prevention of primary non-contact ACL injuries. Modified from Hewett TE et al. NAJSPT 2010

A potential benefit of undertaking a preseason assessment is to target additional preventative measures in the players exhibiting a higher risk (i.e. players showing an increased knee valgus loading during landing). However, it is crucial to underline that, if you decide to undergo a screening test you should use the test result to act on modifiable risk factors.

11.5 Reduction of Secondary Injuries

A last aspect of injury prevention measures is don't forget about secondary injury prevention (strategies to reduce the likelihood of the same injury the player is recovering from). It is accepted, as we stated above, that the single and strongest risk factor for a certain injury is having had the same injury before. This is a principle everybody should consider. The aim of secondary prevention is to lower the injury risk to the level of the other players (not previously injured players). The critical example is the 2nd ACL injury rate in younger players that can be as high as 36% (1 out of 3).

Two important aspects should be considered:

1. *Optimize functional recovery during the rehabilitation period.* Rehabilitation after severe injury (i.e. knee ligament injuries or recurrent high-grade muscle injuries) should always be well structured on evidence-based, injury-specific guidelines. An aspect to be considered in every recovery is the transition between indoor rehabilitation and return to training, when the workloads can dramatically change. In this grey area, a specific on field rehabilitation (OFR) program is recommended to act as a bridge between gym-based rehab and team training to avoid a massive increase in player's load, without adequate preparation. Rehabilitation should be followed by an experienced sport medicine team, especially for severe injuries. Underestimating the recovery from injury can compromise the player's health.
2. *Considering long-term additional preventative measures once the athlete has returned to play.* After effective return to play, a player that sustained a severe injury (i.e. ACL injury) should always consider allocating more time to preventative training. This sort of continuum of treatment, based also on injury specific considerations, may allow a continuous addressing of specific risk factors that may link to recurrent injuries.

11.6 Conclusion

When considering injury prevention (reduction) strategies, it is recommended to adopt a holistic approach. All the environment around the player (i.e. family, coach, agent) not limiting to the sports medicine team should be aware about the injury risk and the benefit of injury prevention training. NMT is effective in reducing the injury risk at a different magnitude based on compliance to the program. In other words, the more you do and the more you reduce the injury risk. Severe injuries, like the ACL injury can be prevented but these programs works only if they are really implemented in the day-by-day practice. Applying the principles and related actions stated in this chapter may allow a reduction in acute and overuse injury risk and a better health for our athletes from youth through to elite professional level.

11.7 Fact Box

- FIFA 11+ program reduces the overall injury risk by 39% in football players
- There is conclusive evidence that injury prevention programs work, reducing ACL injuries by 50% in all athletes and by two-third in female athletes

Reference

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