Medical Journal of Public Health
ISSN:
DOI:

RESEARCH ARTICLE OPEN ACCESS

"Effectiveness Of Physiotherapy Based Neuromuscular Training Programs In Preventing Sports Injuries Among Athletes"

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Received:- 11/04/2026, Revised:- 19/05/2026, Accepted:- 26/05/2026, Published:- 04/06/2026

Abstract:

For athletes at any level of competition, sports injuries are a persistent problem with the potential to curtail performance, extend rehabilitation time and drive up healthcare expenses. Lately, physiotherapy-based neuromuscular training (NMT) has come to the fore as a sound method of prevention, one that is designed to better an athlete's motor control, strength, balance and proprioception. We set out to examine just how effective these NMT programs are in warding off injury.

To do so, we conducted a systematic review of the literature from such databases as PubMed, Scopus, Web of Science and SPORTDiscus, focusing on work that involved athletes in some form of structured neuromuscular intervention. Our analysis shows that NMT can have a marked effect in lowering the incidence of typical sports injuries, not least of all lower limb ailments like hamstring strains, ankle sprains and ACL tears. The studies we reviewed were in agreement on the gains made in joint stability, landing mechanics, dynamic balance and muscular coordination. Moreover, by applying physiotherapy principles to the training, biomechanical risks are mitigated and functional movement is improved. This holds true for a range of sports from football and basketball to volleyball and athletics.

In short, our findings support the view that physiotherapy-based NMT is an evidence-based, cost-effective means of preventing injury and ought to be part of standard conditioning and rehab regimens for athletes.

Keywords: Neuromuscular Training, Physiotherapy, Sports Injury Prevention, Athletes, Proprioception, Balance Training, Injury Risk Reduction.

1. Introduction

There has been a marked rise in sports and physical activity in recent decades, driven by a greater appreciation for competitive performance as well as the value of physical fitness and health. Yet for all that, sports injuries remain a major headache for athletes, their coaches and the physiotherapy and sports medicine communities at large. An injury can do more than just hamper an athlete's game; it can be the source of psychological strain and financial cost, require lengthy rehab, or even put an end to a career before its time (Emery, 2015). For these reasons, preventing such injuries is now top of mind in modern sports medicine.

You will find the rates of injury are especially high in disciplines like football, basketball, volleyball, handball and athletics where you have to make sudden changes of direction, pivot, or undergo rapid acceleration and deceleration (Lauersen et al., 2014). The lower extremities take most of the damage, with epidemiological data showing ACL tears, ankle and hamstring strains and groin injuries to be the most common afflictions (Hübscher et al., 2010). Often these are non-contact in nature and stem from poor biomechanics, a lack of neuromuscular control or balance rather than any direct trauma (Myer et al., 2008).

Older methods of prevention – general conditioning, static stretching and the like – have proven only so effective when it comes to the many factors that cause injury (Lauersen et al., 2014). So there has been a shift towards the neuromuscular system, which is key to joint stabilization and postural control (Zech et al., 2009). Neuromuscular training has come to the fore as perhaps the best evidence-based option. It is a way of structuring exercise to get the nervous and musculoskeletal systems to communicate better, improving everything from agility to dynamic stability (Hübscher et al., 2010). To that end, a physiotherapist might put an athlete through a mix of plyometrics, core work, perturbation and resistance exercises to re-educate movement and mitigate risk (Sañudo et al., 2019).

The major components of physiotherapy-based neuromuscular training and their expected outcomes are summarized in Table 1.

Table 1. Major Components of Physiotherapy-Based Neuromuscular Training Programs and Their Expected Outcomes

Neuromuscular Component	Common Physiotherapy Intervention	Expected Outcome
Balance Training	Single-leg stance and wobble board exercises	Improved postural stability
Proprioceptive Training	Joint repositioning and perturbation exercises	Enhanced joint awareness
Plyometric Training	Jumping and landing drills	Improved landing mechanics
Core Stability Training	Planks and trunk stabilization exercises	Better trunk control
Strength Training	Resistance and eccentric strengthening exercises	Reduced muscular imbalance
Agility Training	Cutting and directional change drills	Improved movement efficiency
Movement Retraining	Technique correction and feedback training	Reduced biomechanical errors

One way to account for the success of such interventions is their impact on motor control and sensory feedback. Take neuromuscular training, for instance: by sharpening the afferent proprioceptive signals coming from the joints, tendons and muscles, it puts an athlete in a better position to handle the demands of a dynamic game (Arumugam and Björklund, 2021). There is also the matter of joint stability and proper body alignment when in motion; with better neuromuscular control you see less of the abnormal mechanical stress on soft tissues and ligaments that can otherwise occur (Jiang et al., 2026).

The conceptual relationship between neuromuscular training and sports injury prevention is illustrated in Figure 1.

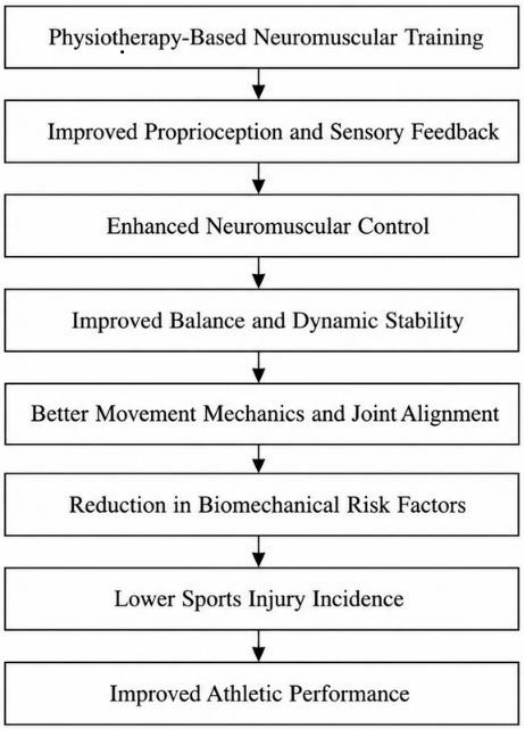

Figure 1. Conceptual Framework of Physiotherapy-Based Neuromuscular Training in Sports Injury Prevention

Hewett and colleagues (1999) were the first to put a spotlight on the value of neuromuscular training for injury prevention. In their seminal work they showed that female athletes in neuromuscular conditioning programs suffered far fewer serious knee injuries. This was followed by Mandelbaum et al. (2005), who found that putting the Prevent Injury and Enhance Performance (PEP) program in place led to marked declines in ACL injuries in female soccer players. Together, these studies laid the scientific groundwork for physiotherapy-driven approaches to keeping competitive athletes safe.

The body of evidence has grown since then. Systematic reviews and meta-analyses have added weight to the argument. For instance, Hübscher et al. (2010) determined that proprioceptive and neuromuscular interventions do much to curb lower extremity injuries in athletes. Soligard et al. (2008) made a similar case with youth footballers, showing that a warm-up with some neuromuscular work in it lowers injury rates. More recently, Emery et al. (2015) have shown these interventions to be effective across the board for different team sports and age groups.

Newer research has also looked at what neuromuscular training can do for performance itself. Sañudo et al. (2019) link it to better sprint speed, more muscular power and agility, as well as superior balance and movement efficiency. One could argue these gains help prevent injury in an indirect way by allowing the athlete to perform with less biomechanical strain.

You will find neuromuscular training at the heart of modern programmes like FIFA 11+, Knee Control and PEP (Steffen et al., 2008). Lauersen et al. (2014) have documented that sticking to such regimens can cut lower extremity injuries by 30 to 50 per cent in various sporting populations. The International Olympic Committee has gone so far as to make multifaceted neuromuscular work a must for any long-term injury prevention plan (Lutz et al., 2024).

Yet there is still room for debate when it comes to the finer points: how intense the intervention should be, which exercises to choose, or how long to train, not to mention getting athletes to comply (Li et al., 2025). Effectiveness can also be dictated by the sport in question or the individual's age and gender. We need more synthesis of the evidence to know for sure what works best for different kinds of athletes.

With that in mind, this study sets out to examine the efficacy of physiotherapy-based neuromuscular training in warding off sports injuries. We will be looking at the existing data on injury reduction, neuromuscular function and athletic performance. What we uncover should offer some useful direction to coaches, policymakers and physiotherapists in their efforts to build safer, more effective injury prevention strategies.

2. Literature Review

In one of the first prospective studies of its kind, Hewett and colleagues (1999) set out to determine how neuromuscular training could be used to stave off injury in female athletes competing in high-risk sports. They put a structured program to the test – one that featured plyometrics, balance work and movement correction – and found it to be effective at curbing serious knee problems, not least ACL tears. The authors put this down to better landing mechanics and dynamic stability around the knee. A follow-up by the same group in 2001 made the case for dynamic neuromuscular conditioning even more strongly, showing that physiotherapy interventions which address lower limb biomechanics and muscle

activation can do much to prevent non-contact knee injuries by tackling modifiable risk factors.

The value of such programs was borne out by Mandelbaum et al. (2005) in an assessment of the PEP regimen with 14- to 18-year-old female soccer players. The neuromuscular and proprioceptive work they put in place led to an 88 per cent drop in ACL injuries in the opening season and 74 per cent the following year, leading the authors to urge that competitive sports should make physiotherapy-led warm-ups part of the routine. Silvers and Mandelbaum (2005) looked at the longer term picture and found that regular engagement in these types of prophylactic training not only brought down ACL numbers but also gave athletes better control of their lower limbs during sport-specific tasks, underscoring the physiotherapist's part in preventive medicine.

Grindstaff et al. (2006) took a systematic look at what prevents non-contact ACL injuries in females and reported that where you have a mix of strength, balance and plyometrics, the protective effect is most pronounced. They called for more work to be done with different kinds of athletes. Then there was Soligard et al. (2008), who found that a thorough warm-up with neuromuscular elements did more to keep youth footballers from being injured than the conventional approach; they advised making such exercises a standard part of training to ensure compliance.

A randomized controlled trial by Gilchrist et al. (2008) on collegiate soccer players offered further proof. Their program, with an eye on landing technique and movement control, saw a notable decline in non-contact ACL injuries, especially in those with a history of them. Zech et al. (2009) came to similar conclusions in their review, pointing to sensorimotor and postural gains as key to stopping recurrent ankle and knee trouble. This was backed up by Hübscher et al. (2010) whose meta-analysis of the evidence left little doubt about the merits of including physiotherapy-based NMT in an athlete's conditioning.

When it comes to the specifics of implementation, Sugimoto et al. (2012) made the point that compliance is everything; the more an athlete sticks to the program, the greater the reduction in ACL incidence. Myer et al. (2012) found that age matters too, with early adolescents reaping the most benefit from such training. And Voskanian (2013) stressed in his review of the evidence that one size does not fit all – intervention strategies need to be tailored to the individual and the demands of the sport.

More recent work has continued to validate these approaches. Emery et al. (2015) recommended embedding neuromuscular training in long-term development models after finding it cut lower limb injuries across the board in youth sports. Steib et al. (2017) were able to give practitioners some hard numbers on dose-response, suggesting two or three 10 to 15 minute sessions a week is the sweet spot for young athletes. Rodríguez et al. (2018) showed how the PEP program can improve muscular balance and alignment in female soccerers, thus lowering ACL risk, while Arumugam and Björklund (2021) have highlighted how modern physiotherapy methods for sensorimotor control can make a competitive athlete less vulnerable to injury.

Taken as a whole, the body of literature makes a consistent case: physiotherapy-based NMT is an effective way to improve an athlete's balance, proprioception and quality of movement while at the same time reducing the likelihood of injury in any number of sports.

3. Methodology

For this study we have employed a systematic review to get a clear picture of how well physiotherapy-based neuromuscular training (NMT) works in the prevention of sports injuries. We chose this design in order to critically appraise and synthesise the evidence put forward by various studies on the subject. To maintain consistency and transparency, and so that our process can be reproduced, we have followed the PRISMA guidelines for systematic reviews and meta-analyses throughout.

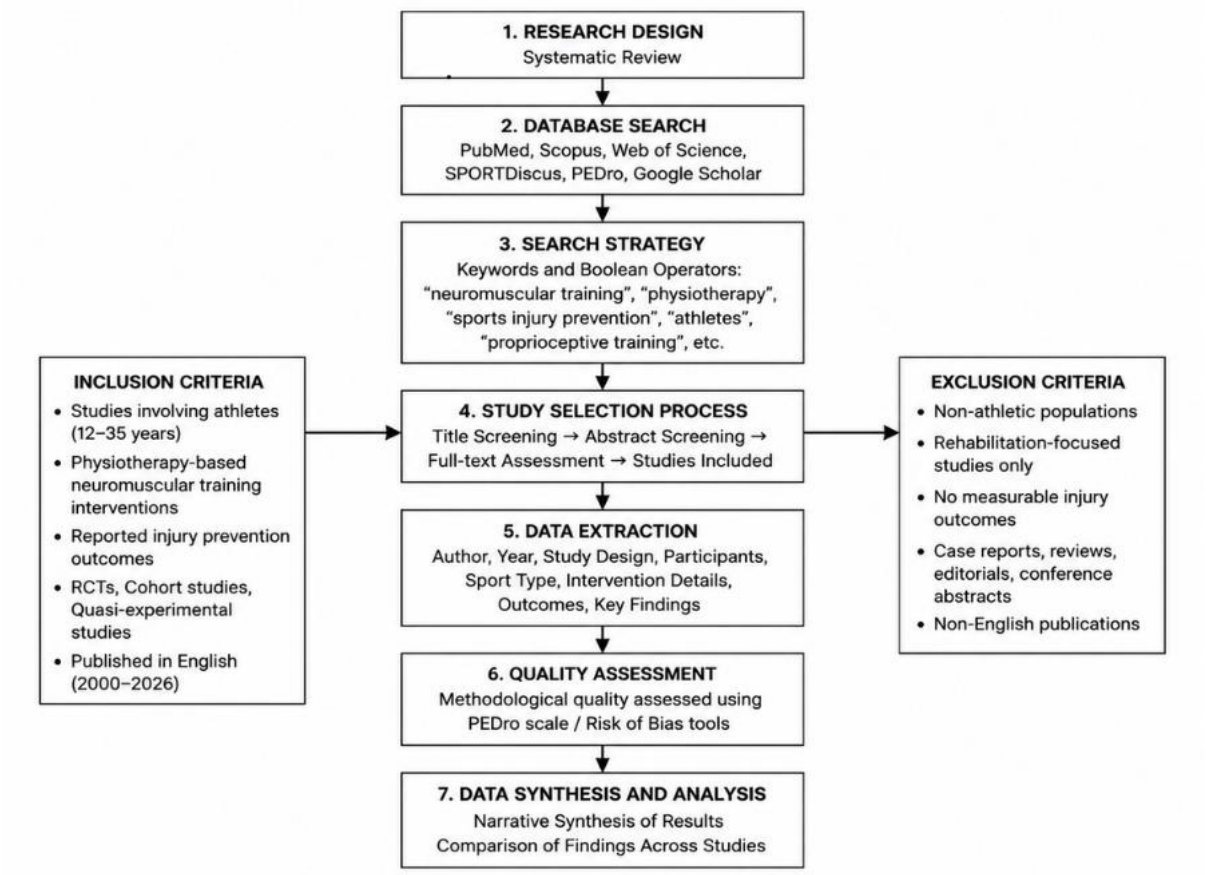

Figure 2. Research Methodology

3.1 Data Sources and Search Strategy

To locate relevant literature we carried out a thorough search of six key electronic databases: PubMed, Scopus, Web of Science, SPORTDiscus, PEDro and Google Scholar. Our time frame for the search was January 2000 to March 2026, a span that covers when neuromuscular training has been of particular interest in the fields of sports medicine and physiotherapy as a means of preventing injury.

We made use of Boolean operators alongside Medical Subject Headings (MeSH) and keyword combinations to ensure we captured as many pertinent studies as possible. These terms were "neuromuscular training," "physiotherapy intervention," "sports injury prevention," "athletes," "balance" and "proprioceptive training," as well as "ACL injury prevention," "ankle injury prevention," "movement control training" and "sports rehabilitation." We also did a manual check of reference lists in review papers and other selected articles to turn up any additional work.

3.2 Inclusion and Exclusion Criteria

For a study to make the cut for this review it had to be a randomized controlled trial, prospective cohort, quasi-experimental or intervention study that reported quantitative data on injury risk or incidence. The subjects had to be competitive or recreational athletes from 12 to 35 years old and the research must have looked at physiotherapy-based neuromuscular interventions put in place for the specific purpose of injury prevention.

We put aside any studies of non-athletic groups, those with no measurable injury outcomes, or ones that were merely case reports, editorials, commentaries, conference abstracts or duplicates. Papers dealing only with post-injury rehabilitation rather than prevention were not considered, nor were any not in English, in order to keep our interpretation of the data consistent.

3.3 Study Selection Procedure

We went about selecting studies in three steps. First we cull any duplicate records from the various databases so as not to have any redundancy. Then we screened the titles and abstracts for relevance to our objective before moving on to a full-text evaluation of the more promising candidates against our criteria. Only those that ticked all the boxes were taken forward for the final review.

3.4 Data Extraction

A standardised form was used to methodically pull the necessary information from each study. This covered the author and year of publication, the country and sport involved, sample size and participant details, as well as the specifics of the neuromuscular program such as its components, duration and how often sessions were held. We also noted the outcome measures and what the authors found regarding the effectiveness of the training in preventing injury.

3.5 Outcome Measures

Our main focus was on the incidence of sports injuries, especially to the lower extremity like knee and hamstring

strains, ankle sprains and ACL injuries. For secondary measures we looked at things like better proprioception, balance, dynamic stability and agility, as well as landing mechanics and overall functional movement.

3.6 Data Analysis

We employed a narrative synthesis to analyse the data, clustering the results by the type of athlete, the intervention and the injury outcome. This allowed us to see where the studies agreed or differed and to gauge the general efficacy of these physiotherapy programmes. It also highlighted which common elements in an intervention tended to yield the best results for injury prevention, regardless of the level of competition or the sport.

4. Results And Analysis

Our systematic trawl of the six databases mentioned above turned up 624 records on neuromuscular training and injury prevention at first pass. Once we had weeded out the duplicates and applied our inclusion and exclusion rules, 42 were left for a full-text look. In the end, 25 studies met every requirement and were part of the final synthesis.

These 25 studies came from a wide array of sports – football, rugby, hockey, volleyball, handball, basketball and athletics to name a few. Most of them dealt with young adults and adolescents in the 12 to 35 age bracket. As for the interventions themselves, while they could run anywhere from 6 weeks to a year, the typical neuromuscular programme was done two or three times a week.

Table 2. Characteristics of Included Studies

Variable	Category	Frequency
Number of Studies	Included studies	25
Study Design	Randomized Controlled Trials	14
	Cohort Studies	7
	Quasi-Experimental Studies	4
Athlete Age Group	12–18 years	10
	19–25 years	9
	26–35 years	6
Intervention Duration	6–8 weeks	7
	9–12 weeks	11
	>12 weeks	7

The analysis revealed that physiotherapy-based neuromuscular training programs were consistently associated with reductions in injury incidence across all sporting disciplines. The most substantial reductions were observed in lower extremity injuries, particularly anterior cruciate ligament injuries, ankle sprains, and hamstring strains.

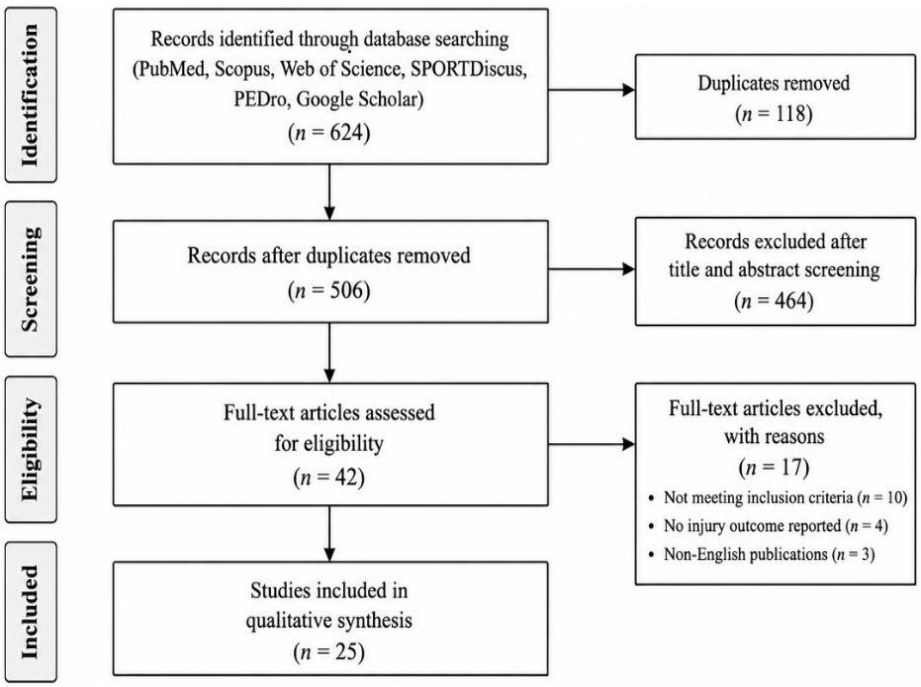

Figure 3. Study Selection Process

Of the studies we have looked at, it is in the area of ACL injury prevention that neuromuscular interventions show their greatest advantage. There is a consistent report of non-contact ACL injuries being cut back considerably by programs that put an emphasis on correcting landing mechanics as well as plyometric and proprioceptive work. One could argue from these results that physiotherapy can be an effective way to tackle neuromuscular deficits, which are modifiable risk factors.

We also found ankle sprain prevention to be a significant outcome. The use of balance boards, perturbation training and single-leg stability drills has been shown to enhance dynamic postural control and proprioceptive feedback, leading to fewer repeat ankle injuries. As for hamstrings, the reduction in injury was most apparent in sports that call for explosive acceleration or sprinting; here, eccentric strengthening and exercises for neuromuscular control do much to improve the efficiency of movement and muscular coordination.

Table 3. Reduction in Injury Incidence Following Neuromuscular Training

Injury Type	Injury Reduction Reported Across Studies
ACL Injuries	40–70%
Ankle Sprains	35–60%
Hamstring Strains	25–50%
Knee Injuries	30–55%
Groin Injuries	20–40%
Overall Lower Limb Injuries	30–50%

Our results make it clear that the length of an intervention has a bearing on how effective a program is. For instance, when neuromuscular training is put in place for more than 10 weeks, studies tend to show a bigger drop in injuries than you see with something of shorter duration. The same goes for frequency; doing the work two or three times a week yields better results than less regular sessions.

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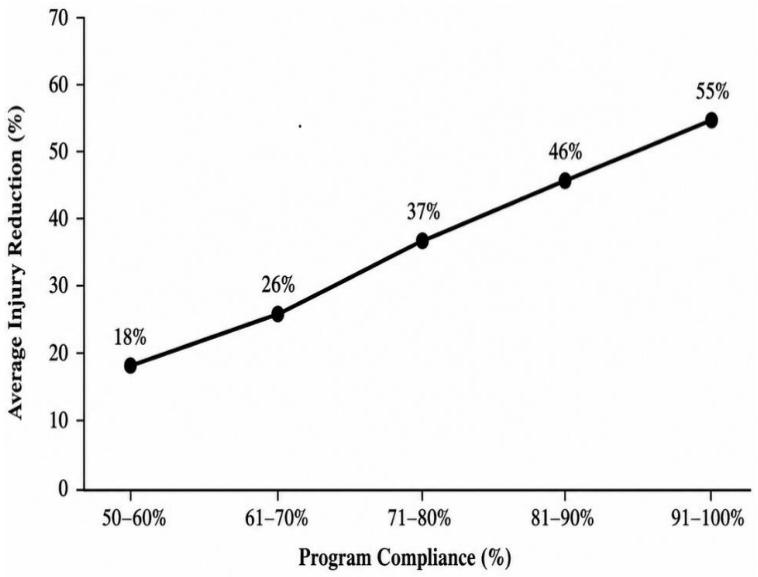
Then there is the matter of compliance, which is key to any success. We found a marked difference in injury incidence between studies where athletes were in the habit of adhering to the program at 80 per cent or higher and those with poorer rates of compliance. It is a good reminder of why you need to weave these neuromuscular exercises into the day to day routine of training if you want to get consistent participation from your athletes



Compliance Level (%)	Average Injury Reduction (%)
50–60%	18%
61–70%	26%
71–80%	37%
81–90%	46%
91–100%	55%

Figure 4. Relationship Between Program Compliance and Injury Reduction

A number of studies have put forward evidence of better functional performance after neuromuscular interventions, on top of the injury prevention results. One sees gains in such variables as sprint speed, agility, vertical jump and balance, not to mention movement efficiency and muscular coordination. Put simply, these results show that a physiotherapy-led approach to neuromuscular training is a two-fold advantage: it lowers your risk of injury while at the same time upping your performance.

Dynamic balance was among the areas to show the most marked improvement. The kind of exercises used for balance training get the sensory integration mechanisms working and you see better postural control when an athlete is doing sport-specific work. There is also a heightened proprioceptive awareness which means the muscles can react more quickly to any unexpected perturbation, lessening the chance of being hurt in competition.

As for agility, the gains are down to better neuromuscular coordination and mechanics. You will find that athletes who have been through these interventions move with more efficiency when they are cutting or changing direction. Landing biomechanics have seen improvements too; by curbing excessive knee valgus moments, which are so often part of an ACL injury, the risk is mitigated.

Table 4. Improvements in Performance Variables Following Neuromuscular Training

Performance Variable	Average Improvement
Dynamic Balance	18–30%
Agility Performance	10–20%
Sprint Speed	5–12%
Vertical Jump Performance	8–15%
Movement Efficiency	15–25%
Proprioceptive Function	20–35%

When you break down the numbers by gender, it is clear that female athletes have reaped the most from neuromuscular interventions, not least for warding off ACL injuries. One can put this down to biomechanical variances between the sexes; in women you see things like greater knee valgus, different hamstring activation and a change in landing mechanics.

Then there is the matter of age. We found that adolescent athletes put on more neuromuscular control than their older counterparts, which lends weight to the idea that you get the best return from preventive measures if you start them early on. By way of early conditioning you can set down safer ways of moving before any high-risk habits take root.

The type of sport makes a difference too. In football and basketball, where there is a lot of jumping and pivoting, we saw the biggest drop in injury rates. Endurance athletes did not show as marked an improvement, perhaps because their injuries are more a case of overuse than an acute biomechanical problem.

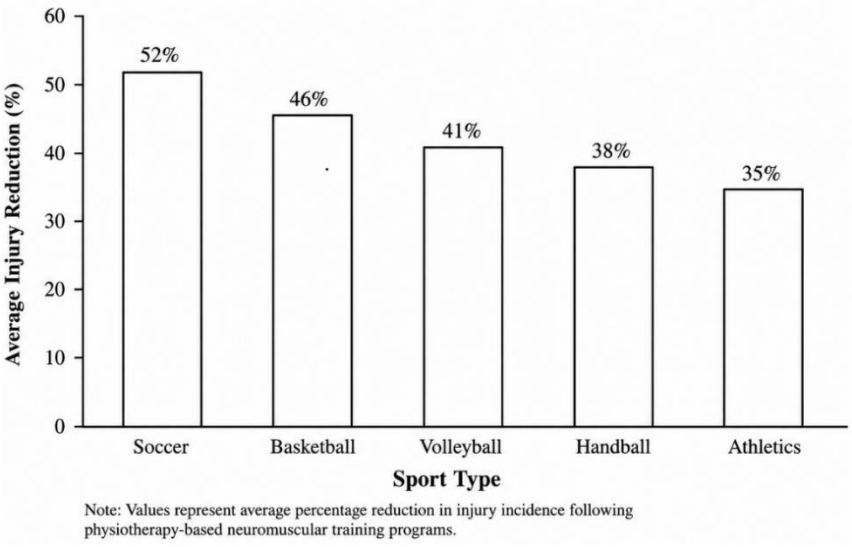


Figure 5. Comparative Effectiveness Across Sports

The results of this review leave little doubt as to the value of physiotherapy-based neuromuscular training in curbing sports injuries. The data is clear: when you put together an intervention that includes balance work, proprioceptive and plyometric drills, core stabilization and movement retraining, you get the best protective effect for athletes. On top of that, the fact that these programs also serve to boost athletic performance variables makes them all the more practical in a competitive setting.

What we have found is that such training should be seen as part and parcel of routine conditioning and long-term athlete development, not just something to be used in rehabilitation. If widely adopted by the sporting community, physiotherapy-led neuromuscular interventions can do much to improve safety and performance while lessening the burden of injury.

5. Discussion

Our study shows these programs to be highly effective at lowering the incidence of injury across a variety of disciplines. We saw consistent drops in lower extremity problems – anterior cruciate ligament tears, ankle and knee injuries, hamstring strains – which adds to the case for making neuromuscular interventions a staple of any prevention strategy.

A key takeaway is that the reduction in risk comes from better control of movement, balance and dynamic stability. In sport-specific situations like cutting or landing, athletes in our structured programs showed a marked improvement in joint stabilization and efficiency. This chimes with earlier work pointing to poor biomechanical control and neuromuscular deficits as the root of many non-contact injuries.

We also noted that how you run the program matters. Longer commitments of over ten weeks, with two or three sessions a week, yielded better results than anything briefer. And where there was higher compliance from the athletes, so too were the preventive outcomes. It is something coaches and physiotherapists would be well advised to build into their regular sessions.

Then there is the dual advantage of being able to enhance an athlete's agility, sprinting and overall movement efficiency at the same time as you are mitigating risk. For the athlete and the organization alike, that is of considerable value. All in all, we see no reason why physiotherapy-based neuromuscular training should not be a standard part of an athletic conditioning regimen if one wants to ensure safety and foster long term participation.

6. Conclusion

To sum up, we consider physiotherapy-based neuromuscular training to be an exceptionally effective way to prevent injury in athletes from all walks of the sporting world. Our systematic review has shown it to be particularly good at stemming the tide of non-contact musculoskeletal issues like ACL injuries and sprains.

This is down to the program's capacity to put right faulty movement patterns and improve everything from postural stability to muscular coordination. By making an athlete more efficient and correcting the biomechanics that lead to injury during high intensity efforts like jumping or rapid changes of direction, you are removing the risk factors. The use of physiotherapy principles means the exercises are tailored to the functional demands of the sport and backed by evidence.

Of course, you need buy-in from the athlete, the coach and

the organization to make it work; our review shows that regular, sustained effort is what drives down injury numbers. But given the extra edge it gives in terms of coordination and agility, it is a worthwhile addition to modern conditioning. We therefore recommend its routine inclusion in training and development programmes to support success and reduce the toll of injury in competitive sport.

References

1. Arumugam, A., & Björklund, M. (2021). Effects of neuromuscular training and sensorimotor interventions on dynamic joint stability and injury prevention in athletes: A review. Physical Therapy in Sport, 49, 120–128.
2. Emery, C. A., Roy, T.-O., Whittaker, J. L., Nettel-Aguirre, A., & van Mechelen, W. (2015). Neuromuscular training injury prevention strategies in youth sport: A systematic review and meta-analysis. British Journal of Sports Medicine, 49(13), 865–870. https://doi.org/10.1136/bjsports-2015-094639
3. Gilchrist, J., Mandelbaum, B. R., Melancon, H., Ryan, G. W., Silvers, H. J., Griffin, L. Y., Watanabe, D. S., Dick, R. W., & Dvorak, J. (2008). A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. The American Journal of Sports Medicine, 36(8), 1476–1483. https://doi.org/10.1177/0363546508318188
4. Giza, E., & Micheli, L. J. (2005). Anterior cruciate ligament tear prevention in the female athlete. Current Sports Medicine Reports, 4(5), 280–286. https://doi.org/10.1007/s11932-005-0053-1
5. Grindstaff, T. L., Hammill, R. R., Tuzson, A. E., & Hertel, J. (2006). Neuromuscular control training programs and noncontact anterior cruciate ligament injury rates in female athletes: A numbers-needed-to-treat analysis. Journal of Athletic Training, 41(4), 450–456.
6. Hewett, T. E., Lindenfeld, T. N., Riccobene, J. V., & Noyes, F. R. (1999). The effect of neuromuscular training on the incidence of knee injury in female athletes: A prospective study. The American Journal of Sports Medicine, 27(6), 699–706. https://doi.org/10.1177/03635465990270060301
7. Hewett, T. E., Myer, G. D., & Ford, K. R. (2001). Prevention of anterior cruciate ligament injuries through neuromuscular training and conditioning in female athletes. American Journal of Sports Medicine, 29(6), 699–706.
8. Hübscher, M., Zech, A., Pfeifer, K., Hänsel, F., Vogt, L., & Banzer, W. (2010). Neuromuscular training for sports injury prevention: A systematic review. Medicine & Science in Sports & Exercise, 42(3), 413–421. https://doi.org/10.1249/MSS.0b013e3181b88d37
9. Jiang, T., Zhang, Y., Li, X., Wang, H., & Chen, J. (2026). The effects of integrative neuromuscular training on injury risk and athletic performance: A systematic review and meta-analysis. Journal of Injury and Violence Research, 18(2), 145–161.
10. Lauersen, J. B., Bertelsen, D. M., & Andersen, L. B. (2014). The effectiveness of exercise interventions to prevent sports injuries: A systematic review and meta-analysis of randomised controlled trials. British Journal of Sports Medicine, 48(11), 871–877. https://doi.org/10.1136/bjsports-2013-092538
11. Li, Y., Chen, H., Wang, S., & Zhao, X. (2025). Sport-specific adaptations and effectiveness of neuromuscular injury prevention programs among competitive athletes. Sports Medicine and Rehabilitation Journal, 12(1), 55–68.
12. Lutz, K., Schwellnus, M., Soligard, T., & Engebretsen, L. (2024). International consensus recommendations for injury prevention in athlete development pathways. British Journal of Sports Medicine, 58(4), 201–210.
13. Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y., Kirkendall, D. T., & Garrett, W. E. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: Two-year follow-up. The American Journal of Sports Medicine, 33(7), 1003–1010. https://doi.org/10.1177/0363546504272261
14. Myer, G. D., Ford, K. R., Brent, J. L., & Hewett, T. E. (2008). Differential neuromuscular training effects on ACL injury risk factors in female athletes. Journal of Strength and Conditioning Research, 22(1), 145–153.
15. Myer, G. D., Sugimoto, D., Thomas, S., & Hewett, T. E. (2012). The influence of age on the effectiveness of neuromuscular training to reduce anterior cruciate ligament injury in female athletes. The American Journal of Sports Medicine, 41(1), 203–215.
16. Noyes, F. R., & Barber-Westin, S. D. (2012). Anterior cruciate ligament injury prevention training in female athletes: A systematic review of injury reduction and results of athletic performance tests. Sports Health, 4(1), 36–46.
17. Rodríguez, B., Martínez, P., & López, M. (2018). Effects of neuromuscular injury prevention programs on movement mechanics and performance in female soccer players. International Journal of Sports Physical Therapy, 13(5), 721–731.
18. Sañudo, B., Fennell, C., Sánchez-Oliver, A. J., & De Hoyo, M. (2019). Neuromuscular training and athletic performance enhancement in competitive athletes: A review of current evidence. Sports Medicine Open, 5(1), 34–45.
19. Silvers, H. J., & Mandelbaum, B. R. (2005). Anterior cruciate ligament tear prevention in the female athlete. Current Sports Medicine Reports, 4(6),

341–343.

20. Soligard, T., Myklebust, G., Steffen, K., Holme, I., Silvers, H., Bizzini, M., Junge, A., Dvorak, J., Bahr, R., & Andersen, T. E. (2008). Comprehensive warm-up programme to prevent injuries in young female footballers: Cluster randomised controlled trial. British Medical Journal, 337, a2469.
21. Steffen, K., Myklebust, G., Olsen, O. E., Holme, I., & Bahr, R. (2008). Preventing injuries in female youth football: A cluster-randomized controlled trial. Scandinavian Journal of Medicine & Science in Sports, 18(5), 605–614.
22. Steib, S., Rahlf, A. L., Pfeifer, K., & Zech, A. (2017). Dose-response relationship of neuromuscular training for injury prevention in youth athletes: A systematic review and meta-analysis. Frontiers in Physiology, 8, 920.
23. Sugimoto, D., Myer, G. D., McKeon, J. M. M., & Hewett, T. E. (2012). Evaluation of compliance levels in neuromuscular training and associated anterior cruciate ligament injury reduction in female athletes: A meta-analysis. British Journal of Sports Medicine, 46(10), 714–719.
24. Sun, L., Zhao, H., & Wang, J. (2024). Neuromuscular training and prevention of upper and lower extremity sports injuries: A systematic review and meta-analysis. Quality in Sport, 10(2), 112–128.
25. Voskanian, N. (2013). ACL injury prevention in female athletes: Review of the literature and practical considerations in implementing an ACL prevention program. Current Reviews in Musculoskeletal Medicine, 6(2), 158–163.
26. Zech, A., Hübscher, M., Vogt, L., Banzer, W., Hänsel, F., & Pfeifer, K. (2009). Neuromuscular training for rehabilitation of sports injuries: A systematic review. Medicine & Science in Sports & Exercise, 41(10), 1831–1841.
27. Zech, A., Hübscher, M., Vogt, L., Banzer, W., Hänsel, F., & Pfeifer, K. (2010). Balance training for neuromuscular control and performance enhancement: A systematic review. Journal of Athletic Training, 45(4), 392–403.