

Effect Of Neuromuscular Training On Injury-Risk Indicators In University Athletes

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Abstract

Sports injuries, especially in the lower limb, are a frequent occurrence amongst university athletes and can have a negative impact on athletic performance and academic studies. Internationally, there is extensive support of neuromuscular training (NMT) as an injury prevention tool, however, there are limited number of structured programs in place in Pakistani Universities, with no evidence of its effectiveness in this population. The aim of this study was to determine the effect of a six-week structured NMT programme on injury-risk indicators in university athletes using a quasi-experimental, single group pre-test–post-test design. Using purposive sampling, 50 athletes (18–25 years) were selected and underwent a supervised NMT programme which took place three times a week for 6 weeks. Pre and post the programme, dynamic balance (Y-Balance Test), landing mechanics (Landing Error Scoring System, LESS), agility (Agility T-test) and injury occurrence were assessed. Data were analyzed using IBM

SPSS Statistics (Version 26); given the change scores' non-normal distribution

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(Shapiro–Wilk, $p < .001$), the Wilcoxon signed-rank test was used within groups, with significance being set at $p < .05$. Dynamic balance improved significantly from a mean composite score of 79.00 to 86.02 ($Z = -7.005$, $p < .001$, $r = .99$). LESS scores fell from 6.88 to 3.78 ($Z = -6.784$, $p < .001$, $r = .96$), indicating fewer landing errors, and Agility T-test time decreased from 11.20 to 10.38 seconds ($Z = -6.551$, $p < .001$, $r = .93$). All the athletes' scores were better on all measures. The number of injuries at pre-test was 56% (28/50) and was 0% at post-test. The results indicate that a short duration and low cost NMT programme can be considered as a useful tool for enhancing movement qualities associated with a reduced risk of lower-limb injuries in university athletes, highlighting the potential for its generalization to a wider context of resource-constrained university sport; however, larger controlled trials are required to validate a causal relationship.

Introduction

The role of the University athlete is unique in that they must train and compete with a high level of physical performance at the same time as they are completing a full academic programme, often without the sports-medicine support that is made available to the professional athlete. Musculoskeletal injury is a constant risk, caused by a combination of high training volumes, tight training and competition schedules, and inadequate professional support, as well as impacting performance beyond sport, on to academic achievement and long-term joint health (McClean et al., 2024).

The most prevalent and debilitating injuries in university sport are to the lower limb, especially the knee and ankle. Anterior cruciate ligament (ACL) tears, ankle sprains and associated non-contact sports injuries tend to occur on landing, cutting and deceleration, which are closely linked with an athlete's ability to control movement and, at least in part, preventable by targeted training. In addition to treating injury after it happens, neuromuscular training (NMT) has become one of the most widely researched approaches to tackling these treatable deficits, focusing on poor balance, weak hip and trunk control, and faulty landing technique (Vivekanandan et al., 2025). Relevant structured neuromuscular warm-up programs have been repeatedly proven to be effective for the decrease of lower-limb injuries, and large syntheses across various sports have found that exercise-based programs with a combination of strength and neuromuscular components are highly effective for reducing acute, as well as overuse injuries. The FIFA 11+ programmes have shown a decrease in overall injury incidence of approximately 30-46% in soccer players and further protective effects have been seen in relation to ankle injuries and acute lower back injury (Amirneni et al., 2024). In a similar multicomponent basketball program, an increase in 36% has been seen in the reduction of ankle and knee injuries in youth athletes using the Shred Injuries warm up. In addition to its injury prevention benefits, integrated NMT has been found to enhance athletic performance parameters like jump ability, and programmes that have been tested are two to five sessions a week for at least nine weeks of the programme, and at least 25 minutes in length (Stanton et al., 2014) .

Field-based screening tools can be used to identify athletes with an increased risk as well as monitor the effects of an intervention. The Y-Balance Test (YBT) assesses dynamic single-leg postural control and poor control in this test is associated with lower-limb injury in collegiate athletes but not in all populations. The Landing Error Scoring System (LESS) is a valid and reliable field-based instrument for evaluation of jump landing quality, and is modified for screening of risk for non-contact ACL injury. These tools together can provide a more comprehensive assessment of neuromuscular competence than either used individually (Rey-Mota et al., 2024).

Nevertheless, in the context of university sport in Pakistan, there is a dearth of dedicated sports-medicine facilities and injury-prevention practice is predominantly informal, despite this significant international evidence-base. The effect of NMT in

this population has not been previously tested as there are training differences, facilities and sporting culture differences. This study thus sought to fill the gap and to assess the effect of a six weeks structured NMT programme on Dynamic Balance, Landing Mechanics, Agility and Injury Occurrence in a cohort of Pakistani University athletes to generate locally relevant evidence to support safe training practice (Aldhahi et al., 2026).

METHODS & MATERIALS

Research Design

The impact of a six-week structured neuromuscular training (NMT) programme on indicators of injury risk in university athletes was examined using a quantitative, quasi-experimental single group pre-test – post-test design. Each participant was his or her own control: outcome measures were taken at the beginning of the programme and at the end of the programme, but the same instruments and procedures were used at both times.

Participants of the Study

The Study participants are the people. People who take part in the Study. Participants were selected from officially established Sports teams in University. All were active, competing members of their respective teams who were training and competing regularly at the time of this study.

Sample and Sample Size

The subjects were 50 athletes of the university aged from 18 to 25 years old, who were recruited through purposive sampling technique. There was no loss to follow up at the end of the 8-week programme, with all 50 athletes completing the full programme and both assessments.

Inclusion Criteria

University athletes between the ages of 18 and 25 years old (both male and female).
Participating currently with an official team from the University in some sport.
Be able to cooperate with all testing and training sessions and give informed consent

Exclusion Criteria

Existence of an acute injury or other musculoskeletal, neurological or cardiovascular condition that would prevent safe participation.

Recent surgery on the lower limbs or advice from doctors not to do strenuous exercise.

Lack of a commitment to the six-week training and testing plan or inability to complete it.

Instruments & Instrumentation

Four outcome measures were taken at pre-test and post-test:

The validated field test for dynamic single-leg postural control is called the Y-Balance Test (YBT). In 3 directions (anterior, posteromedial and posterolateral) the athlete balances on one foot and reaches out maximally with the other, and reaches distances are added together and given as a composite score, with higher scores corresponding to better dynamic balance.

Landing Error Scoring System (LESS) – a field-based biomechanical assessment scoring errors which occur during a standardized task that involves jumping in and landing (e.g. insufficient knee/hip flexion, dynamic knee valgus, asymmetrical landing). A lower score will demonstrate safer landing mechanics.

Agility T-test – A pre-established test of change of direction agility that requires forward sprinting, shuffling laterally and backpedaling through a T-shaped course. Time taken to complete in seconds was recorded – the shorter the time, the more agile. Injury Occurrence Record – a categorical (yes/no) record of whether each athlete had injured any parts of the lower limb in the period of time immediately preceding each assessment.

Exercise Intervention

The intervention group underwent the structured NMT programme three times a week for six weeks, plus their usual sport training. The balance/proprioceptive activities, plyometric jump landing drills, lower-limb strengthening, core strengthening and agility/sport-specific movement activities were all incorporated into each session with focus on proper landing technique and controlled change of direction. The difficulty of tasks was advanced over the 6 weeks based on the ability of each athlete, and the dose and component structure that was found to be effective in the literature (Cormier et al., 2022). Monitoring of adherence occurred throughout session.

Progressive Training Structure

The six-week programme followed a general three-stage progression in training difficulty, summarized below.

Phase & Timeline	Primary Focus	Progression
Foundation (Weeks 1–2)	Establish correct balance, landing and movement technique	Lower-intensity balance, proprioceptive and basic landing drills
Development (Weeks 3–4)	Build plyometric and strength capacity	Increased plyometric and strengthening volume as technique improves
Progression (Weeks 5–6)	Maximize neuromuscular and agility demands	Higher-intensity plyometric, agility and sport-specific integration

Assessment of Data

Data were collected at two time points: pre-training and post-training (after six weeks). Dynamic balance, landing mechanics and agility were assessed using the YBT, LESS and Agility T-test respectively, and injury status was recorded categorically. Collected data were analyzed statistically to compare pre- and post-intervention scores.

Validity and Reliability of Instruments

The YBT, LESS and Agility T-test are widely used, validated field-based tools for assessing dynamic balance, landing quality and agility. Standardized testing procedures, a single examiner and a standardized warm-up prior to testing were used at both time points to maximize the reliability of the measurements.

Mode for Data Collection

All pre-test and post-test assessments were conducted by the same examiner under standardized conditions in a defined indoor space of the university sports complex, using identical instruments and procedures at both time points to ensure that pre–post comparisons were valid.

Ethical Consideration

Ethical approval was obtained from the applicable institutional research ethics review committee prior to data collection (Ref. No. [add reference number]). The purpose, procedures, risks and benefits of the study were explained to all participants, and

written informed consent was obtained from each athlete before enrolment. Participation was voluntary, withdrawal was possible at any time without penalty, and participant data were kept confidential and secure throughout

Data Analysis

Data were analyzed using IBM SPSS Statistics (Version 26). Descriptive statistics (mean, standard deviation, minimum, maximum) were computed for each continuous outcome at pre-test and post-test, and injury occurrence was summarized using frequencies. Difference (post-test minus pre-test) scores for the three continuous outcomes were tested for normality using the Kolmogorov–Smirnov (Lilliefors-corrected) and Shapiro–Wilk tests. As the assumption of normality was violated for all three difference scores ($p < .001$), within-group pre–post comparisons were made using the non-parametric Wilcoxon signed-rank test, with an effect size ($r = Z/\sqrt{N}$) calculated for each comparison. Change in the categorical injury variable was intended to be assessed using the McNemar test for paired nominal data. The significance level for all analyses was set at $p < .05$.

PRESENTATION OF DATA

Table 1

Descriptive Statistics for the Outcome Measures at Pre-Test and Post-Test (N = 50)

Variable	N	Minimum	Maximum	Mean (SD)
Y-Balance (pre)	50	75.0	83.0	79.00 (2.56)
Y-Balance (post)	50	82.0	90.0	86.02 (2.54)
LESS (pre)	50	5.0	9.0	6.88 (1.17)
LESS (post)	50	2.0	5.0	3.78 (1.02)
Agility T-test, s (pre)	50	10.8	11.6	11.20 (0.26)
Agility T-test, s (post)	50	10.0	10.7	10.38 (0.23)

Note. Higher Y-Balance scores indicate better dynamic balance; lower LESS scores and lower Agility T-test times indicate better landing mechanics and agility, respectively.

As shown in Table 1, all three continuous outcomes changed in the direction of improvement from pre-test to post-test. The Y-Balance composite score increased on average from 79.00 to 86.02, the LESS score decreased from 6.88 to 3.78 (fewer landing errors), and Agility T-test time decreased from 11.20 to 10.38 seconds (faster change-of-direction performance).

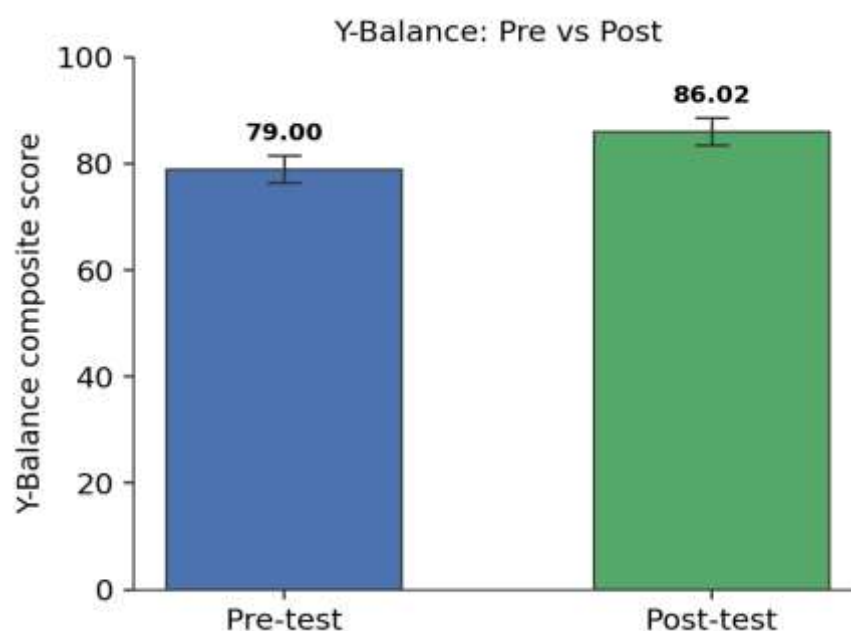


Figure 1. Mean Y-Balance Composite Score Before and After the Intervention

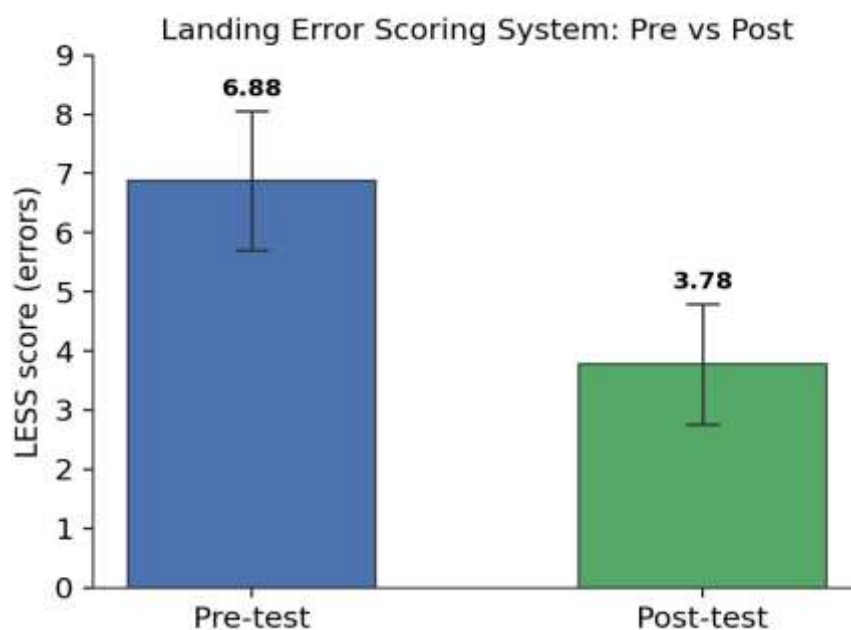


Figure 2. Mean LESS Score Before and After the Intervention

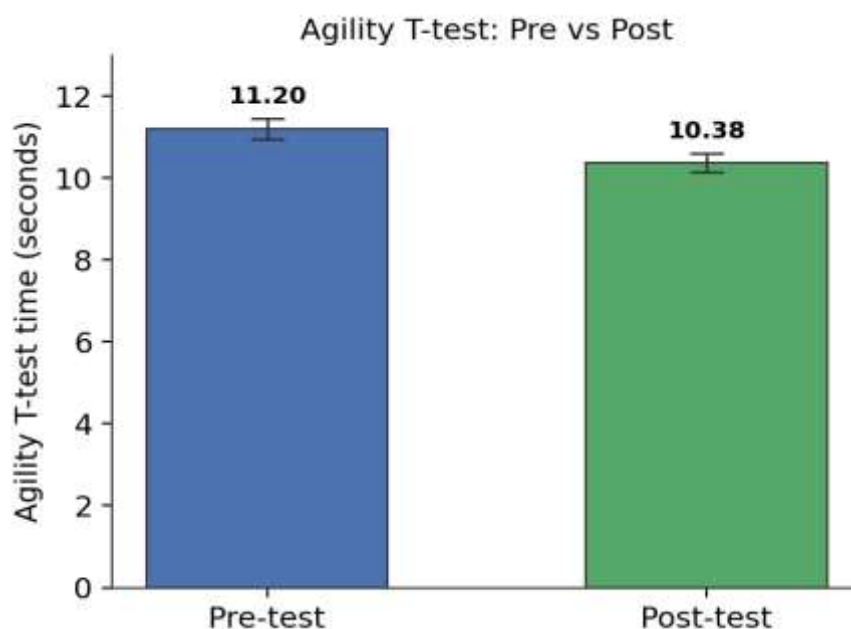


Figure 3. Mean Agility T-test Time Before and After the Intervention

Table 2

Frequency of Injury Occurrence Before and After the Intervention (N = 50)

Injury Status	Pre-Test n (%)	Post-Test n (%)
Yes (injured)	28 (56.0)	0 (0.0)
No (not injured)	22 (44.0)	50 (100.0)
Total	50 (100.0)	50 (100.0)

Injury was reported by more than half of the athletes prior to the intervention (28 athletes, 56%). Following the six-week programme, no athlete reported an injury (0%), a descriptive reduction of 100% in the sample. Because the post-test injury variable was constant (no variability), the McNemar test could not be calculated, and the change is reported descriptively rather than inferentially.

Figure 4. Distribution of Injury Status Before the Intervention

Table 3*Tests of Normality for the Pre–Post Difference Scores*

Difference Score	K–S Statistic	df	Sig.	S–W Statistic	df	Sig.
Y-Balance	.536	50	< .001	.125	50	< .001
LESS	.529	50	< .001	.344	50	< .001
Agility T-test	.480	50	< .001	.511	50	< .001

Note. K–S = Kolmogorov–Smirnov (Lilliefors-corrected); S–W = Shapiro–Wilk. A significant result ($p < .05$) indicates departure from normality.

All three difference scores departed significantly from a normal distribution ($p < .001$ for both tests), so the non-parametric Wilcoxon signed-rank test was used for all within-group pre–post comparisons.

Table 4*Wilcoxon Signed-Rank Test for Dynamic Balance (Y-Balance Test)*

Ranks	N	Mean Rank	Sum of Ranks
Negative ranks (post < pre)	0	0.00	0.00
Positive ranks (post > pre)	50	25.50	1275.00
Ties (post = pre)	0	—	—

Note. $Z = -7.005$, $p < .001$, $r = .99$ (large effect). Median score increased from 79.0 (pre) to 86.0 (post); every athlete improved.

Dynamic balance improved significantly following the NMT programme. The null hypothesis of no change was rejected, indicating a significant improvement in dynamic balance.

Table 5*Wilcoxon Signed-Rank Test for Landing Mechanics (LESS)*

Ranks	N	Mean Rank	Sum of Ranks
Negative ranks (post < pre)	50	25.50	1275.00
Positive ranks (post > pre)	0	0.00	0.00
Ties (post = pre)	0	—	—

Note. $Z = -6.784$, $p < .001$, $r = .96$ (large effect). Median score fell from 7.0 (pre) to 4.0 (post); every athlete improved.

Landing mechanics improved significantly, with all athletes recording fewer errors at post-test. The null hypothesis was rejected, indicating a significant reduction in landing errors following the programme.

Table 6*Wilcoxon Signed-Rank Test for Agility (Agility T-test)*

Ranks	N	Mean Rank	Sum of Ranks
Negative ranks (post < pre)	50	25.50	1275.00
Positive ranks (post > pre)	0	0.00	0.00
Ties (post = pre)	0	—	—

Note. $Z = -6.551$, $p < .001$, $r = .93$ (large effect). Median time fell from 11.2 s (pre) to 10.4 s (post); every athlete was faster.

Agility improved significantly following the programme, with every athlete completing the course faster at post-test. The null hypothesis was rejected.

Table 7*Summary of Wilcoxon Signed-Rank Test Results (N = 50)*

Outcome	Median (pre)	Median (post)	Z	p	r
Y-Balance	79.0	86.0	-7.005	< .001	.99
LESS	7.0	4.0	-6.784	< .001	.96

Agility T-test (s)	11.2	10.4	-6.551	< .001	.93
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Note. r = effect size ($Z/\sqrt{N}$); all effects were large. Injury occurrence decreased from 28/50 (56%) at pre-test to 0/50 (0%) at post-test.

Overall, the NMT programme produced statistically significant, large-magnitude improvements in dynamic balance, landing mechanics and agility, alongside a complete descriptive reduction in recorded injuries across the sample.

DISCUSSION

In the current study, the impact of a six-week structured NMT programme on indicators of injury risk in fifty university athletes was assessed in a single group pre-test–post-test design (Belamjahad et al., 2024). All three continuous outcomes showed significant improvement and the percentage of athletes who reported injury reduced from 56% to 0%, mirroring the overall international evidence that implementing neuromuscular training programs leads to a decreased risk of injury. Dynamic balance (Y-Balance composite score) has improved from 79.00 to 86.02 ($Z = -7.005$, $p < .001$), with all athletes seeing improvement (Maleki et al., 2026).

This is an important result, since less reach distance and asymmetry in the lower limb on dynamic balance tests have been associated with increased risk for lower-limb injuries in collegiate athletes and the extent of change seen in this study is comparable to that found in systematic-review literature on NMT (Gu et al., 2025). Landing mechanics also showed a significant improvement, with the mean scores for LESS improving from 6.88 to 3.78 ($Z = -6.784$, $p < .001$). This decrease indicates that LESS was a reliable and valid measure of higher-risk landing patterns, and that the plyometric and technique aspects of the programme were effective in teaching athletes how to land with more knee flexion and hip flexion, and a more symmetrical loading pattern, which are thought to be factors in the protective effect of NMT against non-contact ACL injury (Maleki, Minoonejad, & Mousavi, 2026). Agility, as measured by the Agility T-test, was also found to improve ($Z = -6.551$, $p < .001$) from a mean of 11.20 to 10.38 seconds, which further demonstrated the dual aspect of NMT for both injury risk reduction and athletic performance previously reported (Foqha et al., 2023).

The fact that some improvement in agility was gained over such a short, logistically achievable period of training (six weeks, three sessions per week) shows that some useful performance gains may be achieved over a relatively short period of training. The most striking descriptive result was that the proportion of injury cases decreased from 56% to 0% in the sampling. No athlete was injured in the post-test, and thus the injury variable remained constant and the planned McNemar test could not be computed, making the change only reported descriptively, not inferentially (Hollerbach, 2019). The finding should therefore be viewed with caution, but is broadly consistent with other reported decreases in injuries at similar levels, including a 36% decrease in ankle and knee injuries among youth basketball players after implementing a neuromuscular warm-up and ~30% decreases in injuries among soccer players after introducing FIFA 11+ (Ltifi et al., 2024).

The uniformity of improvement in each of the 50 athletes and each of the three continuous measures reinforces the conclusion that such improvements are not the result of chance variation but do show the impact of the program (Gonzalo-Skok et al., 2023). The programme was very simple in terms of equipment, training was done in the athletes' training space and after six weeks significant improvements were observed, suggesting that NMT is achievable in a resource-poor country like Pakistan within the context of university sport. The conclusions from the single-group design, small sample size, and lack of a separate control group, however, are limited by the potential of natural improvement, test familiarity/comparable training, and the need to temper the causal strength of the conclusions made (Ltifi¹ et al., 2024).

Strengths of the Study

Utilizes widely recognized and validated field-based screening protocols (Y-Balance Test, LESS & Agility T-test) based in the sports-injury literature. Comprehensively evaluates multiple, complimentary indicators of injury risk (balance, landing mechanics, agility) and actual injury occurrence providing a more comprehensive assessment of neuromuscular adaptation than any single measure.

The intervention was conducted in the athletes' usual training setting using a very limited number of equipment, showing the feasibility of the intervention in resource-constrained university sport contexts. Measurement error is minimized and pre- and post-test scores are comparable due to standardized testing conditions, one examiner and consistent procedures at both testing time points.

Provides one of the first locally generated evidence of the effectiveness of NMT in the Pakistani University athletes and a clear gap in the international literature. No dropouts were noted in the 6-month follow-up, which enhanced the completeness of the pre-post comparison. Weaknesses of the Study The outcome of a single group pre-test-post-test design with no separate control group does not necessarily prove that the changes were due to the intervention.

Small purpose sample (N = 50) studied at a single university setting, that is, the results are not generalisable. The duration of the intervention was brief (six weeks) and there was no follow-up beyond this, making it unclear how long the benefits will last.

The number of athletes injured was zero, resulting in a constant post-test injury variable so a planned McNemar test could not be computed, and the findings of the injury was descriptive only. Some of the improvement may have been due to a learning/familiarity effect from repeated use of the same outcome measures.

Attendance was used as a method of monitoring adherence and individual training effort but was not used as an objective method of monitoring adherence and individual training effort for each session.

Weaknesses of the Study

The pre test – post test design with one group only does not have an independent control group, so that it is difficult to definitively credit the improvements to the intervention alone.

Generalizability was limited, as the sample was relatively small (N = 50) and purposive sampling was used with subjects from a single university setting.

The intervention period was short (six weeks) with no longer-term follow-up, so the durability of the improvements is unknown. Planned McNemar test was not possible as the post-test injury variable was not different (no athlete injured), and injury finding was descriptive only.

There may have been a "learning effect" or "familiarity effect" on some of the outcomes observed since the same outcomes were used repeatedly over time. Attendance was used to monitor adherence and individual training effort but there was no other objective documentation of this for each session.

Future Implications

Randomised Controlled Trials: Future studies should employ a separate group of participants who receive usual training to isolate the causal effect of NMT from natural improvement and to test familiarity, using a randomized controlled design.

Additional larger and more diverse samples across sports and universities would increase the generalizability of the results to the wider population of university athletes. Long-term follow-up (beyond the period of intervention) would help to determine if improved movement quality is maintained across a complete competitive season.

Prospective Injury Surveillance: A yes/no record of injuries would provide a less sensitive estimate of the programme's impact on the incidence of actual injuries.

Implementation and Coach-Education Research: Further research is needed to explore the feasibility of sustaining the delivery of the NMT programs by coaches in resource limited contexts and also the quality of coaching implementation.

CONCLUSION

The effect of a six-week structured neuromuscular training programme on injury-risk indicators was assessed in fifty university athletes from Pakistan, in a single group pre-test–post-test design. There was a significant and large effect on dynamic balance, landing mechanics and agility, with all athletes improving on all continuous measures. The proportion of the sample with a history of injury dropped from 56% to 0% – a very large descriptive change in keeping with the protective effect of neuromuscular training that has been reported internationally. The findings indicate that a short, inexpensive NMT programme can be embedded into the resources available to the sport of university in Pakistan and lead to significant changes in movement qualities associated with risk of lower-limb injuries. Because of the small sample size and single-group study design, the conclusions that can be drawn are limited, and conclusions with greater degree of causation should be based upon larger randomized controlled trials with longer follow-up periods to validate these results and to develop clear guidelines for the use of NMT as part of the routine university athletic training program.

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