Original Article

Effects of Neuromuscular Training with and Without Kinesio-Tape on Pain, Range of Motion, Balance and Function in Footballer with Ankle Sprain

Aamir Gul Memon[1,2,3*], Suriyakala Perumal Chandran[2], Annosha[4], Tahira Zakir[5], Muhammad Sulaman[6]

ABSTRACT

OBJECTIVE: To determine the effects of neuromuscular training with and without kinesio-tape on pain, range of motion, balance, and function in footballers with ankle sprain.
METHODOLOGY: The randomized control trial was conducted at the Pakistan Sports Board, Lahore, from March to August 2023. The Squeeze and Talar Tilt Test purposefully identified thirty male football players who sustained grade I and II ankle sprains. Assigned to group A randomly, neuromuscular training alone (control n=15) and group B neuromuscular training with kinesio-tape (experimental n=15). Both groups performed neuromuscular training for 15–20 min for 4 weeks (three times per week), and after each session, Kinesio-tape was applied to the experimental group. Pain Intensity was evaluated with the Numerical pain rating scale (NPRS), range of motion (ROM) was measured by goniometer, dynamic balance status was assessed with the Star excursion balance test (SEBT), and ankle function was assessed with functional ankle ability measure (FAAM-Sports Subscale).
RESULTS: After 4 weeks of intervention, both groups significantly improved all outcome measures. However, there was significant improvement (p<0.001) in intragroup analysis in all outcome measures after treatment in both groups with p< 0.001. Additionally, the between-group analysis revealed significantly more significant improvements in pain reduction, ROM, balance, and sports function in Group B compared to Group A.
CONCLUSION: Both treatments significantly improved pain, range of motion (ROM), balance, and functional outcomes. However, the group receiving neuromuscular training supplemented with Kinesio Tape exhibited greater effectiveness in ankle sprain.

KEYWORDS: Football player, Kinesio-Tape, Neuromuscular Training, Pain, Range of Motion

INTRODUCTION

Ankle inversion sprains are common in athletics, with over 40% recurring after the initial incident. Recurrent sprains may stem from mechanical instability (MI) and functional ankle instability (FAI), characterized by laxity in joint motion and sensations of ankle instability, respectively[1]. While MI and FAI can coexist, not all individuals with recurrent sprains exhibit gross mechanical instability. Following sprains, disrupted mechanoreceptors in ligaments and joint capsules impair joint position sense (JPS) and kinaesthetic sense, leading to improper foot positioning and delayed neuromuscular response, thereby increasing susceptibility to reinjury[2]. In Western countries, nearly one ankle sprain transpires daily per 10,000 persons, resulting in over two million annual treatments in emergency departments across the United States and the United Kingdom. Sport-related incidents contribute significantly, constituting 16%-40% of all trauma cases[3]. Athletic activity accounts for about 40% of all traumatic ankle injuries, with basketball (41.1%), American football (9.3%), and soccer (7.9%) exhibiting the highest incidence rates. Notably, ankle sprains are more prevalent among females, children, and participants in indoor and court sports[4].

The management of acute ankle sprains involves a multifaceted approach. While the traditional RICE therapy lacks robust evidence, cryotherapy is commonly used for short-term pain relief and to minimize swelling[5]. Analgesic medications, particularly NSAIDs, offer short-term benefits but should be used cautiously due to potential adverse effects. Support is preferred over stabilization and rigid immobilization; however, ankle braces are more effective than other supports[6]. The initiation of weight bearing and exercise therapy depending on the progression of bony healing as well as ROM, stretching, strengthening, and neuromuscular training should be regarded as an essential issue in the treatment aimed at the improvement of the outcomes and the reduction

[1]*Department of Physical Therapy, Riphah International University, Lahore, Punjab, Pakistan*
[2]*Lincoln University College, Malaysia*
[3]*School of Basic Medical Science, Shandong University, China*
[4]*Moomal Institute of Physiotherapy and Allied Health Sciences, Hyderabad, Sindh, Pakistan*
[5]*Physical Therapy Department, Suleman Roshan Medical College, Tando Adam, Sindh, Pakistan*
[6]*University of Lahore, Sargodha Campus, 10 KM Lahore-Sargodha Rd, Sargodha, Punjab, Pakistan*
***Correspondence:** aamir_mmn642@yahoo.com*
doi: 10.22442/jlumhs.2024.01174
Received: 18-07-2024 Revised: 21-10-2024
Accepted: 29-10-2024 Published Online: 24-12-2024

of the frequency of the relapses. Integrating sport-specific manoeuvres in managing the injury is critical in regaining functionality and returning to the field[7]. MAL may be used for pain relief and enhancement of the patient's active range of motion. In summary, besides the application of these treatments, it is also critical to employ a treatment plan that is unique to every client to achieve the best results in the rehabilitation of acute ankle sprain[8].

The following phase in rehabilitating ankle sprains is the neuromuscular and proprioceptive phase to regain balance and postural control. One may hypothesize that abnormal co-activation and timing of muscle activity following an injury are dangerous since they are likely to cause functional instability and high reinjury risk. These exercises are performed to decrease the level of subjectivity, improve the functional status, and minimize the rates of reoccurrence[9]. Social mobilization in the first week after the injury using neuromuscular training interventions has been proven to be safe and effective in enhancing higher activity without increasing pain or swelling. Thus, during the entire rehabilitation period, such exercises, including sensorimotor drills and surface-based activities, should be included to enhance the therapy results and avoid re-injury[10].

Kinesio taping is immensely relevant in the treatment of ankle sprains because of the numerous purposes it serves. It helps immobilize and stabilize the ankle joint and reduces further movements that can cause harm in the healing process[11]. The taping technique plays a part in the alleviation of pain by managing the pressure over injured tissues and positioning the ankle joint correctly. Also, Kinesio taping increases proprioception, thus helping the body to be alert to the joint's position and movements, which aids in restoring normal muscle movements and preventing further injuries[12]. Further, the unique structure aids in the proper lymph flow, helping address swelling, which is typical of an ankle sprain. It is explained, however, that while it is adherent and can stick on the skin surface for an extended period, Kinesio tape does not limit any movements as it factors functional movements and muscle contractions into its assistance and support[13]. Specifically, using Kinesio taping allows patients with ankle sprains to start the therapeutic physical exercises earlier than if they had been treated conventionally, permitting them to get back to regular use of their ankles in the shortest time[14].

Footballers are more vulnerable to such injuries; thus, identifying the most helpful physical therapy process could help them perform better in football-related activities and reduce the probability of recurrence of the injury. Despite these findings, this study could be helpful to clinicians in charge of formulating intervention strategies for these athletes. Thus, this study aimed to compare neuromuscular training with and without kinesio tape for footballers with ankle sprains in pain, joint range of motion, balance and functional recovery.

METHODOLOGY

Study Protocol: A parallel-group, assessor-blinded, Randomized Control Trial (RCT) to assess the efficacy of interventions took place between March and August 2023 at the Pakistan Sports Board in Lahore. This clinical trial was registered with the trial registration number **NCT06198270**. Ethical approval was obtained from the research ethical committee at Riphah International University. Informed consent was obtained from all participants, and measures were taken to ensure the confidentiality and privacy of participant data. Steps were taken to minimize potential risks and protect participants from harm, providing the study was conducted fairly and unbiasedly.

Participants: Researchers adopted a non-probability convenient sampling strategy to enlist 38 footballers aged 18-30. Inclusion criteria required participants to have played sports for at least a year and to participate in 15–20-hour training sessions. Those meeting predetermined criteria for grade I and II ankle sprains were included. The subjects were divided into two equal groups: Group A (control group) and Group B (experimental group).

Outcome Measurement: The pain intensity was measured by the Numeric Pain Rating Scale (NRS), with a higher score indicating more intense pain. The ankle dorsiflexion and plantar-flexion range were measured by goniometer, and the dynamic balance was calculated using the Star Excursion Test, a lower score indicating poor balance. Ankle function is assessed by the FAAM-Sports Scale, and a higher score indicates a better functional status. The 20-m sprint test was used to calculate speed, and a lower time(sec) showed a higher speed.

Interventions:

Over four weeks, each group received twelve treatment sessions. Every intervention was given one-on-one by a physiotherapist with eight years of clinical experience treating musculoskeletal diseases, particularly sports injuries and rehabilitation, and formal training in NMT. At the initial consultation, all interventions were initiated immediately following recruitment. Additionally, they were instructed to apply ice to the damaged ankle area directly for 10-15 minutes at least three times a day and to elevate their injured leg on pillows while they slept. The ankle and subtalar range of motion exercises were among the non-weight-bearing exercises performed in extended sitting positions. Each set consisted of 15 repetitions. Calf muscle stretches were performed five times and held for 30 seconds each time[15]. In both groups, the exercise regimen started after the first therapy session. This course was created to increase proprioception and improve ankle joint mobility and muscle strength. Patients were recommended to cease exercising if their pain increased by more than three on the NPRS and to resume exercise only if their pain returned to baseline after five minutes. The workup settings were changed if necessary, but the kind of exercise remained the same.

Group A and B, NMT completed 12 sessions divided into 4 weeks. The intervention consisted of 6 neuromuscular exercises (3 sets, ten reps each) engaged in neuromuscular training, emphasizing activities that enhance neuromuscular control, balance, and stability[16]. This program included cross-arm single-leg stances, throwing/receiving a ball, single-leg deadlifts, calf lifts, lateral jumps with hands on the hip, and balancing board exercises. Improving proprioceptive awareness and sensorimotor integration in the ankle joint was the goal[17]. Additionally, Group B received K-Tape applications, which provide additional sensory input and support to the ankle, enhancing the effects of the neuromuscular training program. Both groups performed five sets of exercises thrice weekly over four weeks.

Statistical Analysis: Collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23 with a statistical significance level set at p=0.05. Normal data distribution was assessed using the Shapiro-Wilk test, and parametric tests were applied. Independent T-test for within-group and Paired test for between-group analysis.

RESULTS

Thirty-eight patients participated in the study, and two athletes dropped out due to long institutional distance. There were a total *n*=19 participants in Group A & *n*=19 participants in Group B. The demographic characteristics, expressed as means and standard deviations, provide a comprehensive overview of the study population. For the alone neuromuscular training group, the mean age was 21.47±3.11, with an average weight of 61±9.99 and a height of 5.57±0.3. Conversely, the neuromuscular training with the kinesio-tape group exhibited a mean age of 22.27±2.58, a mean weight of 62.67±4.42, and a mean height of 5.65±0.3 (**Table I**).

Table I. The demographic characteristics of the subjects (Mean± Standard deviation)

Measurement Index	Neuromuscular training (Group A)	Neuromuscular Training with Kinesio-Tape (Group B)
Age (years)	21.47 (SD = 3.11)	22.27 (SD = 2.58)
Weight (kgs)	61.0 (SD = 9.99)	62.67 (SD = 4.42)
Height (feet)	5.568 (SD = 0.3)	5.654 (SD = 0.3)

The results in **Table II** showed significant improvements across various outcome measures post -intervention. Pain intensity, as measured by the Numeric Pain Rating Scale (NPRS), significantly decreased from an average of 3.9±0.89 to 2.6±0.83, with a mean difference of 1.3±0.03 (p < 0.001). The dorsiflexion range of motion increased from 18.7±1.44 degrees to 21.3±1.03 degrees, while plantar flexion improved from 38.8±1.7 degrees to 42.5±3.2 degrees, showing mean differences of 2.5±0.41 and 3.7±2.5 degrees, respectively. Balance, assessed using the Star Excursion Balance Test (SEBT), significantly improved with a mean score increase from 48.9±7.36 to 60.6±3.9, resulting in a mean difference of 11.7±3.46. Additionally, the Foot and Ankle Ability Measure (FAAM) scores rose from 44.7±4.7 to 50.2±5.07, indicating a mean difference of 5.47±0.37.

Table II: Pre and Post results of neuromuscular training alone

Outcome measures	Pre-values	Post-values	Mean Difference	p-value
NPRS	3.9± 0.89	2.6±0.83	1.3±0.03	**<0.001**
Dorsi-flexion	18.7±1.44	21.3 ±1.03	2.5±0.41	
Planter-flexion	38.8±1.7	42.5±3.2	3.7±2.5	
SEBT	48.9±7.36	60.6±3.9	11.7±3.46	
FAAM	44.7±4.7	50.2±5.07	5.47±0.37	

NPRS= Numerical Pain Rating Scale, dorsi and planter flexion were measured in degrees, SEBT=Star Excursion Balance Test, FAAM= Foot and Ankle Ability Measure, Sports subscale

The experimental group exhibited significant improvements across all measured outcomes following the intervention. Pain intensity, as measured by the Numeric Pain Rating Scale (NPRS), showed a dramatic reduction from a pre-intervention mean of 4.6±0.97 to a post-intervention mean of 1.0±0.76, resulting in a mean difference of 3.6±0.21 (p < 0.001). The dorsiflexion range of motion increased significantly, with mean values rising from 19.9±1.3 degrees to 23.6±1.84 degrees, indicating a mean difference of 3.7±0.54 degrees. Similarly, plantar flexion improved substantially, with mean values increasing from 38.1±2.55 degrees to 44.9±2.87 degrees, yielding a mean difference of 6.8±0.32 degrees. The Star Excursion Balance Test (SEBT) assessed that balance improved markedly, with mean scores increasing from 46.3±6.65 to 66.9±5.4, reflecting a mean difference of 20.6±1.25. Additionally, as measured by the Foot and Ankle Ability Measure (FAAM) Sports Scale, functional performance showed a significant enhancement, with mean scores rising from 45.5±6.1 to 62.3±7.5, resulting in a mean difference of 16.87±1.4. These results underscore the intervention's effectiveness in significantly reducing pain, improving range of motion and balance, and enhancing functional performance in the experimental group. **Table III**

The between-group analysis revealed that the Neuromuscular Training with Kinesio-Tape (Group B) was significantly more effective across various outcome measures than Neuromuscular Training alone (Group A). Pain intensity, as measured by the Numeric Pain Rating Scale (NPRS), showed a significantly more significant reduction in Group B (mean difference of 3.6±0.21) compared to Group A (mean difference of 1.3±0.03, $p < 0.05$). Dorsiflexion range of motion improvement was more pronounced in Group B (mean difference of 3.7±0.54) than in Group A (mean difference of 2.5±0.41). Similarly, plantar flexion showed a more significant increase in Group B (mean difference of 6.8±0.32) compared to Group A (mean difference of 3.7±2.5). Balance, as assessed by the Star Excursion Balance Test (SEBT), improved significantly more in Group B (mean difference of 20.6±1.25) than in Group A (mean difference of 11.7±3.46). Furthermore, functional performance, measured by the Foot and Ankle Ability Measure (FAAM), showed a greater enhancement in Group B (mean difference of 16.87±1.4) compared to Group A (mean difference of 5.47±0.37). These results indicate that adding Kinesio-Tape to neuromuscular training significantly enhances the effectiveness of the intervention across all measured outcomes. **Table IV**

Table III:
Pre and Post results of Experimental Group

Outcome measures	Pre-values	Post-values	Mean Difference	p= value
NPRS	4.6±0.97	1.0±0.76	3.6±0.21	**<0.05**
Dorsi-flexion	19.9±1.3	23.6±1.84	3.7±0.54	
Planter-flexion	38.1±2.55	44.9±2.87	6.8±0.32	
SEBT	46.3±6.65	66.9±5.4	20.6±1.25	
FAAM Sports-Scale	45.5±6.1	62.3±7.5	16.87±1.4	

NPRS= Numerical Pain Rating Scale, dorsi and planter flexion were measured in degrees, SEBT=Star Excursion Balance Test, FAAM= Foot and Ankle Ability Measure, Sports subscale

Table IV: Differences of Pre &Post results between control and experimental group

Outcome measures	Neuromuscular training (Group A)	Neuromuscular Training with Kinesio-Tape (Group B)	Mean Difference	*p*-value
NPRS	1.3±0.03	3.6±0.21	1.3±0.03	<0.05
Dorsi-flexion	2.5±0.41	3.7±0.54	2.5±0.41	
Planter-flexion	3.7±2.5	6.8±0.32	3.7±2.5	
SEBT	11.7±3.46	20.6±1.25	11.7±3.46	
FAAM	5.47±0.37	16.87±1.4	5.47±0.37	

DISCUSSION

This study explored the effect of neuromuscular training with and without kinesio tape on pain, range of motion, balance, and function in male football players with ankle sprain. After 4 weeks of training, Results demonstrated significant improvements across various outcome measures post-intervention for both groups, with the experimental group exhibiting substantially more substantial gains. Pain intensity, as measured by the Numeric Pain Rating Scale (NPRS), showed a more pronounced reduction in the experimental group (mean difference of 3.6±0.21) compared to the control group (mean difference of 1.3±0.03, $p < 0.05$). Enhancements in dorsiflexion and plantar flexion ranges of motion were more significant in the experimental group, with mean differences of 3.7±0.54 and 6.8±0.32 degrees, respectively, compared to 2.5±0.41 and 3.7±2.5 degrees in the control group. Balance improvements, assessed using the Star Excursion Balance Test (SEBT), were greater in the experimental group (mean difference of 20.6±1.25) than in the control group (mean difference of 11.7±3.46).

Furthermore, functional performance, measured by the Foot and Ankle Ability Measure (FAAM), exhibited a more substantial enhancement in the experimental group (mean difference of 16.87±1.4) compared to the control group (mean difference of 5.47±0.37). These findings indicate that adding Kinesio-Tape to neuromuscular training significantly enhances the effectiveness of the intervention across all measured outcomes. These findings align with studies emphasizing the positive impact of exercise-based interventions on pain reduction in individuals with ankle sprains[18-20].

A study demonstrated a significant decrease in ankle pain after nine sessions of MWM treatment for grade two lateral ankle sprains[21]. In addition to ankle sprains, numerous other musculoskeletal pain conditions, including low back pain[22], neck pain[23], chronic musculoskeletal pain in elderly individuals[24], chronic pain following primary total knee arthroplasty[25], and osteoarthritis in the knee and hip, can be effectively treated with neuromuscular exercise (NME)[26]. It has been suggested that affected persons engage in multimodal active workouts, termed "exercise-induced hypoalgesia", because they may help control pain by lowering sensitivity to noxious stimuli and activating endogenous pain-inhibitory pathways[27]. In contrast, a review reported no significant change in compressive or thermal pain after one MWM session for similar injuries[28]. The differences in treatment duration, pain type, and dosage may explain these discrepancies.

Assessment of range of motion (ROM) in dorsiflexion and plantar flexion revealed significant improvements in both groups. Group B showed greater improvements in dorsiflexion (3.7 degrees, $p < 0.001$) and plantar-flexion (6.8 degrees, $p < 0.001$) compared to Group A (dorsiflexion: 2.5 degrees, $p < 0.001$; plantar-flexion: 3.7 degrees, $p < 0.001$). These results are consistent with studies highlighting the effectiveness of exercise interventions in improving ankle joint mobility[29,30]. Studies revealed that ankle inversion/eversion ROM changes were significantly lower in Kinesio-taped ankle conditions[31,32].

The Star Excursion Balance Test (SEBT) results demonstrated substantial improvements in balance for both groups, with Group B showing a significantly more significant mean difference of 20.6 units (p <0.001) compared to Group A's mean difference of 11.7 units (p <0.001). The previous study examined the potential of KT to increase ankle stability through improved proprioception; KT has also been proposed to enhance muscle activation[33]. Current and prior studies align with the literature emphasizing the positive impact of exercise interventions, mainly neuromuscular training, on balance enhancement[34,35].
Regarding functional improvements assessed through the Foot and Ankle Ability Measure (FAAM) Sports-Subscale, both groups showed notable increases. However, Group B exhibited a significantly higher mean difference of 16.87 points (p < 0.001) compared to Group A's mean difference of 5.47 points (p <0.001), indicating superior functional outcomes with Neuromuscular Training. These results resonate with research emphasizing the effectiveness of exercise interventions in enhancing functional outcomes in individuals with ankle sprains[36,37]. The results are also consistent with existing literature, highlighting the positive impact of targeted exercise interventions in individuals recovering from ankle sprains[38,39].
The observed improvement in symptoms (pain, ROM, and balance) with neuromuscular training may be attributed to its focus on neuromuscular control and functional adaptations in individuals with ankle sprains. Future studies should investigate the sustained effectiveness of pain reduction following Neuromuscular Training compared to manual therapy and biomechanical changes in ankle sprain patients.

CONCLUSION

The study concluded that both treatment groups have significantly improved the symptoms. However, integrating neuromuscular training with K-tape application exhibits heightened effectiveness in mitigating pain, enhancing range of motion (ROM), and augmenting functional outcomes, surpassing outcomes observed in the control group. This efficacy is evident in both intra-group and inter-group comparisons.

Ethical permission: Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University, Lahore, Pakistan ERC letter No. REC/RCR & AHS/23/33.

Conflict of Interest: No conflicts of interest, as stated by authors.

Financial Disclosure / Grant Approval: No funding agency was involved in this research.

Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Memon AG: Conception and design, Data Analysis and interpretation, Article Drafting
Chandran SP: Conception and design, Critical revision for the important intellectual content
Annosha: Data Collection, Literature search
Zakir T: Data Collection, Assembly of data
Sulaman M: Data collection

REFERENCES

1. Wen Z, Lyu R, Wang W, Hua X, Yu Y, Zeng K, Kong L, Wang J. The effect of Tuina based on the concept of hip-knee-ankle conjugation in patients with chronic ankle instability: study protocol for a randomized controlled trial. Front Rehabil Sci. 2023; 4: 1165548. doi: 10.3389/fresc.2023. 1165548.
2. Tamura A, Shimura K, Inoue Y. Leg and Joint Stiffness of the Supporting Leg during Side-Foot Kicking in Soccer Players with Chronic Ankle Instability. Sports. 2023; 11(11): 218.
3. Halabchi F, Hassabi M. Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. World J Orthop. 2020; 11(12): 534-558
4. Desai SS, Dent CS, Hodgens BH, Rizzo MG, Barnhill SW, Allegra PR, Popkin CA, Aiyer AA. Epidemiology and outcomes of ankle injuries in the National Football League. Orthop J Sports Med. 2022; 10(6): 23259671221101056.
5. Ramamurthy JP, Sharmil H, Sathya P. Effect of Ultrasound therapy and Cryotherapy over Tapping technique in patients with Acute Lateral Ankle Sprain. Int J Life Sci Pharma Res. 2021; 11(4): 9-15.
6. Altomare D, Fusco G, Bertolino E, Ranieri R, Sconza C, Lipina M et al. Evidence-based treatment choices for acute lateral ankle sprain: a comprehensive systematic review. European Review for Medical & Pharmacological Sciences. 2022; 26(6).
7. Karartı C, Özyurt F, Basat HÇ. Biomechanics, pathomechanics, diagnosis, treatment, and return to play criteria of lateral ankle sprains: an evidence-based clinical guideline. Journal of Orthopedics Research and Rehabilitation. 2023; 1 (2): 37-43.
8. de Ruvo R, Russo G, Lena F, Giovannico G, Neville C, Turolla A et al. The Effect of Manual Therapy Plus Exercise in Patients with Lateral Ankle Sprains: A Critically Appraised Topic with a Meta-analysis. J Clin Med. 2022; 11(16): 4925
9. Jungmann PM, Lange T, Wenning M, Baumann FA, Bamberg F, Jung M. Ankle sprains in athletes: current epidemiological, clinical and imaging trends. Open Access J Sports Med. 2023: 29-46.
10. De Kock BL, Van der Gragt J, Van der Molen HF, Kuijer PP, Zipfel N. What personal and work-related characteristics of Dutch construction workers with knee osteoarthritis are associated

with future workability? J Occup Environ Med. 2023; 65(3): 271-6.
11. Karakoyun ÖF, Karakoyun ZN, Yüce Yörük EA, Coşkun MB, Gölcük Y. The impact of ankle kinesio taping on pain management in patients with acute ankle sprain. Ulus Travma Acil Cerrahi Derg. 2024; 30(4): 248-253.
12. Li Y, Xia Y, Zhang D, Fu S, Liu M, Pan X et al. Immediate effect of kinesiology taping on muscle strength, static balance, and proprioception after eccentric muscle fatigue on ankle: a randomized cross-over trial. BMC Musculoskelet Disord. 2024; 25(1): 244.
13. Labianca L, Andreozzi V, Princi G, Princi AA, Calderaro C, Guzzini M et al. The effectiveness of Kinesio Taping in improving pain and edema during early rehabilitation after Anterior Cruciate Ligament Reconstruction: A Prospective, Randomized, Control Study. Acta Biomed. 2022; 92(6): e2021336.
14. Azab AR, Elnaggar RK, Aly SM, Basalem N, Alamri AM, Saleh AK et al. From injury to rehabilitation: How kinesiology taping helps patients with first metatarsophalangeal joint sprain (turf toe) in pain reduction, gait parameters, and functional ability improvement. A randomized clinical trial. Heliyon. 2024; 10(8): e29746.
15. Biz C, Nicoletti P, Tomasin M, Bragazzi NL, Di Rubbo G, Ruggieri P. Is kinesio taping effective for sports performance and ankle function of athletes with chronic ankle instability (CAI)? A systematic review and meta-analysis. Medicina. 2022; 58(5): 620.
16. Gebel A, Prieske O, Behm DG, Granacher U. Effects of balance training on physical fitness in youth and young athletes: a narrative review. Strength Condition J. 2020; 42(6): 35-44.
17. Hoch MC, Hertel J, Gribble PA, Heebner NR, Hoch JM, Kosik KB et al . Effects of foot intensive rehabilitation (FIRE) on clinical outcomes for patients with chronic ankle instability: a randomized controlled trial protocol. BMC Sports Sci Med Rehabil. 2023; 15(1): 1-3.
18. Miranda JP, Silva WT, Silva HJ, Mascarenhas RO, Oliveira VC. Effectiveness of cryotherapy on pain intensity, swelling, range of motion, function, and recurrence in acute ankle sprain: A systematic review of randomized controlled trials. Physical Therapy Sport. 2021; 49: 243-9.
19. Halabchi F, Hassabi M. Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. World J Orthop. 2020; 11(12): 534.
20. Arcanjo FL, Martins JV, Moté P, Leporace G, de Oliveira DA, de Sousa CS et al. Proprioceptive neuromuscular facilitation training reduces pain and disability in individuals with chronic low back pain: A systematic review and meta-analysis. Complement Ther Clin Pract. 2022; 46: 101505.
21. Nguyen AP, Pitance L, Mahaudens P, Detrembleur C, David Y, Hall T et al. Effects of Mulligan mobilization with movement in subacute lateral ankle sprains: a pragmatic randomized trial. J Manual Manipulative Ther. 2021; 29(6): 341-52.
22. Taulaniemi A, Kankaanpää M, Tokola K, Parkkari J, Suni JH. Neuromuscular exercise reduces low back pain intensity and improves physical functioning in nursing duties among female healthcare workers; secondary analysis of a randomized controlled trial. BMC Musculoskelet Disord. 2019; 20(1): 328.
23. Lee J-D, Shin W-S. Immediate effects of neuromuscular control exercise on neck pain, range of motion, and proprioception in persons with neck pain. Phys Ther Rehab Sci. 2020; 9(1): 1-9.
24. Sit RWS, Choi SYK, Wang B, Chan DCC, Zhang D, Yip BHK et al. 42. Neuromuscular exercise for chronic musculoskeletal pain in older people: a randomized controlled trial in primary care in Hong Kong. Br J Gen Pract. 2021; 71(704): e226–e36.
25. Larsen JB, Skou ST, Arendt-Nielsen L, Simonsen O, Madeleine P. Neuromuscular exercise and pain neuroscience education compared with pain neuroscience education alone in patients with chronic pain after primary total knee arthroplasty: study protocol for the NEPNEP randomized controlled trial. Trials. 2020; 21(1): 218.
26. Holm PM, Petersen KK, Wernbom M, Schrøder HM, Arendt-Nielsen L, Skou ST. Strength training in addition to neuromuscular exercise and education in individuals with knee osteoarthritis-the effects on pain and sensitization. Eur J Pain. 2021; 25(9): 1898–1911.
27. Karamanlioglu DS, Kaysin MY, Begoglu FA, Akpinar P, Ozkan FU, Aktas I. Effects of acupuncture on pain and function in patients with subacromial impingement syndrome: A randomized sham-controlled trial. Integr Med Res. 2024: 101049.
28. Norouzi A, Delkhoush CT, Mirmohammadkhani M, Bagheri R. A comparison of mobilization and mobilization with movement on pain and range of motion in people with lateral ankle sprain: A randomized clinical trial. J Bodywork Movement Ther. 2021; 27: 654-60.
29. Vallandingham RA, Gaven SL, Powden CJ. Changes in dorsiflexion and dynamic postural control after mobilizations in individuals with chronic ankle instability: a systematic review and meta-analysis. J Athletic Train. 2019; 54(4): 403-17.
30. Ahern L, Nicholson O, O'Sullivan D, McVeigh JG. Effect of functional rehabilitation on the performance of the star excursion balance test among recreational athletes with chronic ankle instability: a systematic review. Arch Rehabil Res Clin Transl. 2021; 3(3): 100133.
31. Sarvestan J, Ataabadi PA, Svoboda Z,

Kovačikova Z, Needle AR. The effect of ankle Kinesio™ taping on ankle joint biomechanics during unilateral balance status among collegiate athletes with chronic ankle sprain. Physical Therapy Sport. 2020; 45: 161-7.

32. Akbar S, Soh KG, Jazaily Mohd Nasiruddin N, Bashir M, Cao S, Soh KL. Effects of neuromuscular training on athletes physical fitness in sports: A systematic review. Front Physiol. 2022; 13: 939042.
33. Biz C, Nicoletti P, Tomasin M, Bragazzi NL, Di Rubbo G, Ruggieri P. Is kinesio taping effective for sports performance and ankle function of athletes with chronic ankle instability (CAI)? A systematic review and meta-analysis. Medicina. 2022; 58(5): 620.
34. Gebel A, Prieske O, Behm DG, Granacher U. Effects of balance training on physical fitness in youth and young athletes: a narrative review. Strength Condition J. 2020; 42(6): 35-44.
35. Hoch MC, Hertel J, Gribble PA, Heebner NR, Hoch JM, Kosik KB et al. Effects of foot intensive rehabilitation (FIRE) on clinical outcomes for patients with chronic ankle instability: a randomized controlled trial protocol. BMC Sports Sci Med Rehabil. 2023; 15(1): 1-3.
36. Abdelhaleem MD, Abdelhay MI, Aly SM, Abdallah EA, Neamat Allah NH. Effects of 6 weeks of ankle stability exercises on pain, functional abilities, and flexibility in patients with chronic non-specific low back pain: a randomized controlled trial. Bull Fac Phys Ther. 2023; 28(1): 14.
37. Mollà-Casanova S, Inglés M, Serra-Añó P. Effects of balance training on functionality, ankle instability, and dynamic balance outcomes in people with chronic ankle instability: Systematic review and meta-analysis. Clin Rehabil. 2021; 35 (12): 1694-709.
38. Jung N. A comparative Evaluation of closed and open kinetic exercises in the management of chronic ankle instability. J Int Acad Physical Ther Res. 2020; 11(4): 2212-20.
39. Chan BH, Snowdon DA, Williams CM. The association between person and fracture characteristics with patient-reported outcome after ankle fractures in adults: A systematic review. Injury. 2022; 53(6): 2340-65.