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EFFECTS OF CLOSED CHAIN EXERCISE VERSUS NEUROMUSCULAR TRAINING ON PAIN AND RANGE OF MOTION IN FOOTBALL PLAYERS WITH CHRONIC ANKLE SPRAIN

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Abstract

Closed chain and neuromuscular training both are believed to enhance the joint stability, proprioception, coordination, balance and agility. This research work revolves around the need to compared the effects of closed chain exercises and neuromuscular training with the aim to identify the optimal rehabilitation approaches for football players with chronic ankle sprain. Objective of the study was to determine the effects of closed chain exercises versus neuromuscular training on pain and range of motion in football players with chronic ankle sprain. The study design was Randomized Clinical Trial. Total 34 subjects of both male and female gender with age 18-35 participated. Non-Probability Convenient Sampling Technique was used. Conducted in Pakistan Sports Board (PSB) Lahore and completed within 10 months. Closed chain and neuromuscular training groups each 17 participants given exercise plans for 4 weeks. Assessment was done by Pain (NPRS) and range of Motion (Goniometer). The data was analyzed using SPSS, 25. Statistical significance was set P= 0.05. Normality of the data assessed by Shapiro-wilk test. The mean age of participants was 23.24±3.78 years. The mean weight was 61.55±7.40 kg and mean height 5.62±0.28 feet. Body mass index in comparison, Group A, Under-weight 29.4% and Normal 70.6% while in Group B Under-weight 11.8% and Normal 88.2Both groups show significant results with p-value <0.05. %. In Group A and Group B both had equal number of Dominant Ankle Right 76.5% and Left 23.5%. While in group A injured ankle Right was 64.7% and Left was 35.3%. In Group B Right injured ankle was 52.9% and left was 47.1%. Both groups show significant results with p-value <0.05 In comparison between group, mean difference showed closed chain better outcomes than neuromuscular training group. This study concluded closed chain exercise have better outcomes in comparison to neuromuscular training in chronic ankle sprain either neuromuscular training group, however also exhibits promising results.

Key words: Ankle, Injuries, Instability, Neuromuscular, Sports, Sprain

Introduction

The most frequent injury in sports i.e. football is a lateral ankle sprain. According to some estimates, players who have suffered this injury have a 75% chance of recurrent ankle sprains (D. Cruz-Díaz, F. Hita-Contreras, A. Martínez-Amat, A. Aibar-Almazán, & K.-M. J. J. o. a. t. Kim, 2020b). Ankle sprains account for 10% to 30% of all sports injuries among athletes, making them one of the most prevalent musculoskeletal injuries (Ferreira et al., 2020). Ankle sprains are most common in athletes who play sports that require them to do functional tasks like jumping, landing, rotating, cutting, tackling, and rapid movements (Khorjahani, Mirmoezzi, Bagheri, & Kalantariyan, 2021).Three ligaments are often seen lateral to the hip. The anterior talofibular ligament is the most susceptible, followed by the calcaneofibular and posterior talofibular ligaments (Kawabata et al., 2023). Twenty percent of the injuries involve both

anterior talofibular ligament and calcaneofibular ligament, with the former accounting for 65% of cases (DESAI, DAMSAM, & PALEKAR, 2022).

It is necessary to understand the true mechanism of damage before making a diagnosis when discussing sprains, particularly those affecting the ankle joint. 85% of ankle sprain injuries result in a plantarflexed foot with increased inversion and adduction, according to the mechanism of injury notes (Ferreira et al., 2020). Additional related variables, such as reduced ankle joint dorsiflexion, changed kinematics, and persistent sensory impairments, affect most patients' day-to-day activities (D. Cruz-Díaz, F. Hita-Contreras, A. Martínez-Amat, A. Aibar-Almazán, & K.-M. Kim, 2020a). Recurrent ankle sprains in athletes cause ankle instability as a result of changed neuromuscular control, proprioception, and kinematics (Huang, Jankaew, & Lin, 2021). When discussing ankle sprains, it is important to consider the mechanism underlying the injury as it relates to various injury patterns (Ferreira et al., 2020). The patho-mechanics of damaged ligaments, as well as mechanical and functional instabilities, affect most sporting activities (Huang et al., 2021). Laxity of the damaged ligaments and decreased proprioception consequently have an indirect impact on the neuromuscular regulation of the ankle joint (Lapanantasin et al., 2022). Thus, the damage caused by an ankle sprain may not just affect the ankle's ligaments but also smaller joints such as the subtalar, transverse, and medial side of the ankle (Ferreira et al., 2020). Some other limitations of arthrokinematics should be considered too including decrease in dorsiflexion range and restriction on posterior talar glide (Lu, Yu, & Gan, 2022).

The prolonged manifestation of ankle sprain symptoms affects not only the ligaments but also the postural control system (Rosen et al., 2017). The lateral side of the ankle ligaments change not only as a result of the initial injury but also when the ligament begins to lax after the injury and may progress to hyperlaxity. Sports involvement among the younger generation has increased recently, and this has led to an increase in overuse injuries. In addition to impacting younger people, those between the ages of 13 and 18 are more vulnerable to overuse injuries than those between the ages of 5 and 12. Adults who participate in several levels of sports are more likely to sustain injuries(Cain, 2018). Additionally, athletes between the ages of 15 and 35 are more likely to experience SAI(Lapanantasin et al., 2022). According to past reports, individuals with higher baseline ages are more vulnerable to injuries, and either short- or long-term follow-up leads to an incomplete recovery(Ferreira et al., 2020).

Higher level athletes use longer training sessions and more severe training. varied sports include varied stress levels, which makes overuse injuries inevitable. Participating in multiple sports also leaves little time for the body to heal(Cain, 2018). Then, these overuse injuries are either improperly treated or go untreated, which has long-term consequences. When comparing genders, adult females are more likely to sustain overuse injuries (Leppänen et al., 2019). Compared to children, adults experience a higher rate of lower extremity injuries, and they frequently do not receive appropriate care for these injuries until they have an impact on their field sports performance(Cain, 2018).

Due to poor outcomes, where pain is often the first symptom reported, an ankle that has shown stability or healed completely may result in associated injuries to the ankle joint. Chronic ankle instability can also lead to osteochondral lesions, and up to 89% of cases of ankle sprains have been reported(Toselli et al., 2022). Ankle sprains are frequently caused by a few other well-known conditions, such as sinus tarsi syndrome or subtalar instability(Ferreira et al., 2020). There are deficits in strength, proprioception, range of motion, and postural sway. Ankle sprains can be strongly predicted by muscle strength and joint proprioception (Rosen et al., 2017).

It is necessary to prevent scar tissue strain during the inflammatory phase of early tissue healing by using functional treatments to preserve the ankle. As the collagen proliferates and matures, it becomes increasingly important to monitor the strength and alignment of newly generated collagen(DESAI et al., 2022). Ankle sprains are typically considered benign injuries that should heal in a few days. This allows for a speedy recovery and a return to intense activities, but it also puts stress on the tissues, which increases the risk of recurrence of the sprain or other injury(Cain, 2018). The physiotherapist can create a more effective rehabilitation programme with the use of all this knowledge about tissue healing(DESAI et al., 2022).

A 6-week plyometric exercise programme was created for athletes to work on after a review of the various exercise training regimens for ankle sprains. This programme enhanced performance by increasing strength, proprioception, and response speed while also reducing ankle instability and postural sway(Lee, Oh, & Kwon, 2020). Plyometric exercises comprise a variety of motions such as hopping, leaping, squatting, and bouncing. The pathophysiology of plyometrics is really stretch-short cycle movements that cause repetitive lengthening and shortening of muscle and tendon complex(Huang et al., 2021).

According to certain research, utilizing a lace-up brace or taping in conjunction with neuromuscular control trainings may be more beneficial for enhancing balance and proprioception when there is sensory input (Luan, Adams, Witchalls, Ganderton, & Han, 2021; Shepherd, 2017). A variety of ankle supports, such as braces and orthoses, are available and can be utilized to improve mechanical stability while limiting joint range of motion (Ergen & Ulkar, 2008).

Materials and Methods

The research employed a Randomized Clinical Trial design. Epitools was used to compute the sample size. Following the inclusion of a 10% attrition rate, 34 patients made up the sample size. The convenient sampling method that is non-probability was applied. The Pakistan Sports Board (PSB) in Lahore was the study's location. Within ten months following the approval of the synopsis, the study was finished. Male and female participants aged 18 to 35, Grades 1 and 2 ankle sprains, recurrent ankle sprains, and ankle sprain specific tests (such as the squeeze test and the talar tilt test) were the inclusion criteria (Allois, Niglia, Pernice, & Cuesta-Barriuso, 2020). Individuals with a history of trauma or an ankle fracture (6 months), vestibular or balance disorders(Alahmari et al., 2021), athletes who had sprained their ankle in the month before the study began(Allois et al., 2020), those taking anti-inflammatory medications, poor physical fitness, and co-morbidities such as acute sprains, dislocated ankles, and inability to play were all excluded. The range of motion (ROM) measure goniometer and the pain (numerical pain rating scale, NPRS) were the data collection tools. Group A (control group) received a closed chain exercise plan from the 17 individuals in the experimental group, while Group B (experimental group) received a neuromuscular training plan from the 17 participants in the experimental group.

RESULTS

Considering socio-demographic variables in sample of 34 participants; total 28(82.4%) male and 6(17.6%) female with the mean age of participants was 23.24±3.78 years. The mean weight was 61.55±7.40 kg and mean height 5.62±0.28 feet. More number of participants were right ankle dominant 76.5% and left ankle 23.5%. Also, there were more injuries of right ankle 58.8% while left ankle 41.4%. After evaluating the Shapiro-Wilk test's normality. The application of a non-parametric test was chosen as p-value <0.05 was used within groups or between two groups. Wilcoxon Sign Rank was applied on baseline values on group A (closed chain exercise) which

was compared with group B (neuromuscular training) on pre-treatment values. In comparison between two groups Group A had male 94.1% and female 5.9% while Group B had male 70.6% and female 29.4%. In Group A mean age was 21.65±3.28 years and in Group B 24.82±3.66 years. Mean weight in Group A was 61.0±9.40 kg and 61.12±4.89kg in Group B. Mean Height in Group A was 5.58±0.28 feet and In Group B 5.64±0.28 feet. Body mass index in comparison, Group A Under-weight 29.4% and Normal 70.6% while in Group B Under-weight 11.8% and Normal 88.2%. In Group A and Group B both had equal number of Dominant Ankle Right 76.5% and Left 23.5%. While in group A injured ankle Right was 64.7% and Left was 35.3%. In Group B Right injured ankle was 52.9% and left was 47.1%.

Figure 1: Body Mass indexes of groups

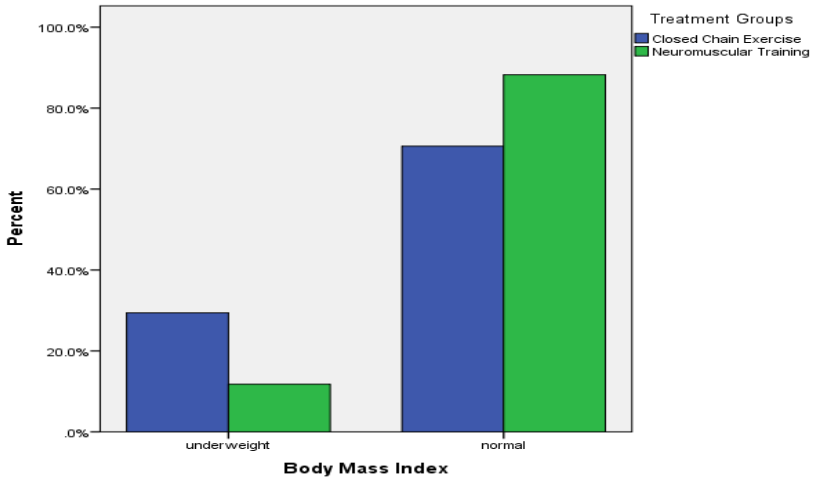

Table 1: Between Groups Comparison of mean Age, Weight, Height

Variables	Group A	Group B
	Mean (SD)	Mean (SD)
Age	21.65(3.28)	24.82(3.66)
Weight	61.0(9.40)	61.12(4.89)
Height	5.58(0.28)	5.64(0.28)

Table 2: Test of Normality.

Variables	Shapiro -wilk test		
	Statistic	df	sign.
Pre-Numerical Pain Rating Scale	.911	34	.009
Pre-Dorsi Flexion	.948	34	.104
Pre-Plantar Flexion	.822	34	.000

Table 3: Within Group Comparison (Wilcoxon signed rank test):

Variables	Group A			Group B		
	Mean ranks	P value	Z value	Mean ranks	P value	Z value
Pre-Numerical Pain Rating Scale	4.53	0.000	1.600	5.06	0.000	1.455
Post-Numerical Pain Rating Scale	1.59			2.41		
Pre-Dorsi-Flexion	21.05	0.000	0.179	21.09	0.000	0.377
Post-Dorsi-Flexion	22.08			21.50		
Pre-Plantar-Flexion	54.4	0.000	0.987	54.34	0.003	0.386
Post-Plantar-Flexion	55.47			54.67		

Table 4: BETWEEN GROUP COMPARISON POST-TREATMENT (Mann-Whitney U Test):

Variables	**Groups**	**Mean Rank**	**P value**	**Z value**
Post-Numerical Pain Rating Scale	Group A	1.59	0.085	-0.824
	Group B	2.41		
Post-Dorsi-Flexion	Group A	22.08	0.088	0.576
	Group B	21.51		
Post-Plantar-Flexion	Group A	55.47	0.016	0.800
	Group B	54.67		

Discussions

The purpose of this study was to compare the effects of neuromuscular training against closed chain exercise on ankle sprains that football players had on their range of motion and pain. 34 football players that fit the inclusion criteria and have a persistent ankle sprain issue were the targeted population. With a gender distribution of 82.4% male and 17.6% female, the average age was 23.24±3.78 years, mean weight was 61.55±7.40 kg, and mean height was 5.62±0.28 feet. A goniometer was used to evaluate range of motion and a numerical pain rating scale was employed to quantify pain.

The study's findings showed that the closed chain exercise group performed better than the neuromuscular training group in terms of significant findings with a p-value of 0.05, suggesting that it was beneficial in treating the symptoms of chronic ankle sprains. It is imperative to recognize the favorable results noted in the neuromuscular training cohort, indicating its potential as a feasible intervention for this demographic.

A greater degree of variation was observed in the pre- and post-assessment of certain variables, such as pain, in both the closed chain and muscle training groups. The results from the closed

chain group were more noteworthy. The total score declined and the severity of the conditions changed, but some players were still unable to continue playing the game, indicating that the 4-week follow-up plan was not as beneficial as it could have been. A longer-term follow-up strategy is required for complete recovery. The discomfort and range of motion (plantar flexion, dorsiflexion) in the current investigation shown substantial differences between pre- and post-assessment outcomes. A prior study found that when it comes to reducing pain and stiffness and enhancing physical function, closed chain exercises are superior to open chain activities(DESAI et al., 2022). An additional investigation demonstrated the noteworthy impact of combining open-chain and closed-chain exercise regimens. This study examined the effects of open and closed chain workouts on youth football players' injuries. assessing pain with the visual analogue scale (VAS) and a tenderness grading system. Exercise and soreness from resistance training both reduced (Pandey, Yadav, Rayjade, Chintamani, & Kolhatkar, 2020).

Ankle sprains can cause injuries to ligaments, tendons, and mechanoreceptors as well as pain, decreased motion, disability, altered kinematics, sensorimotor deficits, and a giving-away sensation in the ankle. These injuries may be the result of mechanical problems with the lower leg muscles and the lateral ligaments of the ankle joint, which can also alter activation strategies and impact the postural control system. Ankle sprains are strongly indicated by deficits in muscular strength and joint proprioception.

(Rosen et al., 2017). For the purpose of main-training joint stability and strengthening opposing muscle groups, strength training can be quite beneficial. Increased muscle tone has been discovered to have a substantial role in creating muscle strengthening and joint stability, particularly in response to unanticipated stressors detected by the joint(Khorjahani et al., 2021). As a result, the joint stiffens when the opposing muscles contract. Recreational athletes with FAI benefit from balance/plyometric training because it increases their awareness of their ankle joints' positions, increases the level of ankle plantar flexor activation just before landing, and leads to more controlled mobility (Huang et al., 2021). Proprioceptive exercises have been shown to reduce pain by increasing ankle plantar flexion and dorsiflexion range of motion. As a result of our study's reduction in pain under load-bearing conditions, football players' athletic performance was able to improve(Allois et al., 2020). Additionally, proprioception shows the ability to discriminate different joint muscle strengths (Khorjahani et al., 2021).

Proprioception and balancing exercises are linked to reaction and control of movement, utilising a vast array of mechano-receptors acting as peripheral afferents for position sensing. Any damage to these peripheral mechano-receptors alters the regulation of neuromuscular transmission and changes the afferent and efferent responses.

(Alahmari et al., 2021). Following the onset of injury, ligaments and joint capsules overstretch and loosen, altering how these mechano-receptors work. Reduced ankle position perception as well as extended peroneal muscle reflex latency have been documented(Jaber et al., 2018). The person must have strong neuromuscular control for optimal postural control during dynamic balance. Movement deficiencies, such as dorsiflexion of the ankle, also impair postural control(Cruz-Díaz et al., 2020a; Jaber et al., 2018). In contrast to a healthy person, the patient's neuromuscular control was altered while walking, as evidenced by an increase in peroneus longus activity prior to initial contact (Jaber et al., 2018). Increased proprioception, strength, and reaction time; also, there was a reduction in ankle instability and postural sway (Lee et al., 2020). The study was limited in that the effects on biomechanical or kinematics parameters, perception of velocity change, sense of force, kinesthesia, and muscle activation were not examined. This investigation's scope was restricted to the Pakistan Sports Board in Lahore. Large-scale randomized clinical trials would be necessary to further understand the relative benefits of closed chain and neuromuscular training in football players with persistent ankle sprains. Future initiatives could be made to lessen any bias resulting from the absence of blindness in order to improve the uniformity of advanced investigations and Future studies should consider longer follow-up times in order to assess the long-term advantages of both treatments. A more comprehensive evaluation of the intervention's effects on football players with persistent ankle sprains would consider proprioception, strength, and quality of life, among other outcomes.

Conclusion

The study's conclusions indicate that closed chain exercise outperformed neuromuscular training in improving football players' discomfort and range of motion after they were treated for chronic ankle sprains. Nonetheless, the neuromuscular training group also shown encouraging outcomes,

with closed chain exercise having a minor advantage in this investigation. These findings suggest that for football players with chronic ankle sprains, neuromuscular training and closed chain training may be helpful therapies.

References

Alahmari, K. A., Kakaraparthi, V. N., Reddy, R. S., Silvian, P., Tedla, J. S., Rengaramanujam, K., & Ahmad, I. (2021). Combined effects of strengthening and proprioceptive training on stability, balance, and proprioception among subjects with chronic ankle instability in different age groups: evaluation of clinical outcome measures. *Indian journal of orthopaedics, 55*, 199-208.

Allois, R., Niglia, A., Pernice, A., & Cuesta-Barriuso, R. (2020). Improvement of Mobility, Strength, Stability and Pain in Soccer Players with Recurrent Ankle Sprains Through Myofascial Release, Strength Exercises and Taping: A Randomized Controlled Trial.

Cain, M. S. (2018). A Randomized Controlled Trial Investigating the Effects of a 4-Week Ankle Rehabilitation Program on High School Athletes with Chronic Ankle Instability.

Cruz-Díaz, D., Hita-Contreras, F., Martínez-Amat, A., Aibar-Almazán, A., & Kim, K.-M. (2020a). Ankle-joint self-mobilization and CrossFit training in patients with chronic ankle instability: a randomized controlled trial. *Journal of athletic training, 55*(2), 159-168.

Cruz-Díaz, D., Hita-Contreras, F., Martínez-Amat, A., Aibar-Almazán, A., & Kim, K.-M. J. J. o. a. t. (2020b). Ankle-joint self-mobilization and CrossFit training in patients with chronic ankle instability: a randomized controlled trial. *55*(2), 159-168.

DESAI, R. R., DAMSAM, A. R., & PALEKAR, T. J. (2022). Efficacy of Open versus Closed Kinetic Chain Exercises on Dynamic Balance and Health Status in Individuals with Osteoarthritis of Knee Joint: A Quasi-experimental Study. *Journal of Clinical & Diagnostic Research, 16*(8).

Ergen, E., & Ulkar, B. (2008). Proprioception and ankle injuries in soccer. *Clinics in sports medicine, 27*(1), 195-217.

Ferreira, J. N., Vide, J., Mendes, D., Protásio, J., Viegas, R., & Sousa, M. R. (2020). Prognostic factors in ankle sprains: a review. *EFORT Open Reviews, 5*(6), 334.

Huang, P.-Y., Jankaew, A., & Lin, C.-F. (2021). Effects of plyometric and balance training on neuromuscular control of recreational athletes with functional ankle instability: a randomized controlled laboratory study. *International Journal of Environmental Research and Public Health, 18*(10), 5269.

Jaber, H., Lohman, E., Daher, N., Bains, G., Nagaraj, A., Mayekar, P., . . . Alameri, M. (2018). Neuromuscular control of ankle and hip during performance of the star excursion balance test in subjects with and without chronic ankle instability. *PloS one, 13*(8), e0201479.

Kawabata, S., Murata, K., Iijima, H., Nakao, K., Kawabata, R., Terada, H., . . . Kanemura, N. (2023). Ankle instability as a prognostic factor associated with the recurrence of ankle sprain: a systematic review. *The Foot*, 101963.

Khorjahani, A., Mirmoezzi, M., Bagheri, M., & Kalantariyan, M. (2021). Effects of trx suspension training on proprioception and muscle strength in female athletes with functional ankle instability. *Asian Journal of Sports Medicine, 12*(2).

Lapanantasin, S., Thongloy, N., Samsee, M., Wonghirunsombat, N., Nuangpulsarp, N., Ua-Areejit, C., & Phattaraphanasakul, P. (2022). Comparative effect of walking meditation and rubber-band exercise on ankle proprioception and balance performance among persons with chronic ankle instability: A randomized controlled trial. *Complementary Therapies in Medicine, 65*, 102807.

Lee, H. M., Oh, S., & Kwon, J. W. (2020). Effect of plyometric versus ankle stability exercises on lower limb biomechanics in taekwondo demonstration athletes with functional ankle instability. *International Journal of Environmental Research and Public Health, 17*(10), 3665.

Leppänen, M., Pasanen, K., Clarsen, B., Kannus, P., Bahr, R., Parkkari, J., . . . Vasankari, T. (2019). Overuse injuries are prevalent in children's competitive football: a prospective study using the OSTRC Overuse Injury Questionnaire. *British journal of sports medicine, 53*(3), 165-171.

Lu, Y., Yu, K., & Gan, X. (2022). Effects of a SMART Goal Setting and 12-Week Core Strength Training Intervention on Physical Fitness and Exercise Attitudes in Adolescents: A Randomized Controlled Trial. *International Journal of Environmental Research and Public Health, 19*(13), 7715.

Luan, L., Adams, R., Witchalls, J., Ganderton, C., & Han, J. (2021). Does strength training for chronic ankle instability improve balance and patient-reported outcomes and by clinically detectable amounts? A systematic review and meta-analysis. *Physical Therapy, 101*(7), pzab046.

Pandey, R. S., Yadav, T., Rayjade, A., Chintamani, R., & Kolhatkar, A. (2020). Effectiveness of open kinematic chain exercises and closed kinematic chain exercises in adductor groin pain in recreational football players. *Indian Journal of Forensic Medicine & Toxicology, 14*(2), 276-282.

Rosen, A. B., Than, N. T., Smith, W. Z., Yentes, J. M., McGrath, M. L., Mukherjee, M., . . . Maerlender, A. C. (2017). Attention is associated with postural control in those with chronic ankle instability. *Gait & posture, 54*, 34-38.

Shepherd, J. (2017). The effects of an ankle strengthening and proprioception exercise protocol on peak torque and joint position sense.

Toselli, S., Mauro, M., Grigoletto, A., Cataldi, S., Benedetti, L., Nanni, G., . . . Fischetti, F. (2022). Assessment of body composition and physical performance of young soccer players: differences according to the competitive level. *Biology*, *11*(6), 823.