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Comparative Effects of Closed-Chain Exercises Versus Mobilization with Movement on Pain, Range of Motion, Balance, and Function in Professional Footballers with Ankle Sprains

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Abstract:

Objective: The purpose of this experimental research was to compare the effects of closed-kinetic-chain exercises (CKCE) versus mobilization with movement (MWM) on pain, range of motion (ROM), balance, and functional outcomes before and after 4 weeks of training in professional footballers with an ankle sprain.

Material and Methods: The football players with inversion ankle sprain (N=40) were equally and randomly assigned to 2 groups. Participants in intervention group A (n=20) received the closed-kinetic-chain exercises, whereas participants in intervention group B (n=20 underwent mobilization with the movement technique. Each participant received the intervention every other day for 4 consecutive weeks. Pain, range of motion, balance, functional ability, and sprint performance were assessed. All outcomes were measured one day before and after the intervention.

Results: Within-group analysis showed significant improvements in pain, range of motion, balance, functional stability, and sprint performance for both CKCE and MWM. Between-group comparisons revealed that MWM was superior in enhancing range of motion and reducing pain, whereas CKCE achieved greater gains in balance, functional stability, and sprint performance.

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Conclusion: Both groups demonstrated statistically significant improvements in pain reduction, range of motion, balance, and functional outcomes in footballers with ankle sprains; however, mobilization with movement was found to be more effective overall compared to closed kinetic chain exercise.

Keywords: Ankle sprain, closed kinetic chain, footballers, mobilization with movement

Introduction

An ankle sprain is one of the most common musculoskeletal injuries, accounting for a significant portion of acute injuries in sports and daily activities[1]. Ankle sprains occur when the ligaments that support an ankle joint are overstretched or torn and have often resulted from inversion or eversion injuries[2]. Risk factors for ankle sprains include poor neuromuscular control, inadequate warm-up, and previous injury history[3]. An ankle sprain is also very common among athletes; studies have shown that the incidence in sports like basketball, soccer, and volleyball is as high as 30%[4], posing risks to both male and female athletes. However, some studies suggest that the incidence may be higher among women due to hormonal and biomechanical reasons[5]. It is also a common injury among children and adolescents involved in sports since it leads to dire inconvenience regarding participation in sports and mobility during the day[4].

A comprehensive physical examination is a necessity in the diagnosis and grading of severity for ankle sprains. Orthopedic examination usually entails palpation of the injured area with subsequent evaluation of swelling and observation of gait patterns[6]. The anterior drawer test and talar tilt test for assessment of ligament integrity are special tests[7]. Physical therapists apply other measurements using goniometry for the measurement of range of motion, dynamometry for the testing of muscle strength, and functional balance tests such as the Star Excursion Balance Test (SEBT)[8]. These evaluations validate the diagnosis, as well as aid in formulating rehabilitation strategies[6].

As ankle sprains are treated differently, the initial management may start right away with medical treatment or extend to longer rehabilitation. The first management is usually in accordance with RICE (rest, ice, compression, and elevation), along with pharmacological pain measures[9]. Physiotherapy is another important treatment that emphasizes controlling the pain, restoring range of motion, and strengthening muscles using techniques like mobilization with movement and closed-chain exercises[10]. These methods are intended to decrease pain, enhance functional mobility, and restore balance. Advanced rehabilitation programs introduce proprioceptive training and sport-specific drills for the prevention of recurrent injuries and maximum return-to-play[11]. Closed-kinetic-chain exercises (CKCE) are performed with the foot in a fixed position on a stable surface, thereby stimulating joint stabilization, muscle co-contraction, and neuromuscular control. These exercises aim at enhancing strength, proprioception, and dynamic stability, simulating daily and sport-specific activities[10]. The Mulligan concept also employs mobilization with movement (MWM), a hands-on method integrating therapist-assisted joint mobilization with active patient movement[12]. Also used widely in ankle-sprain rehabilitation, MWM is applied for the restoration of dorsiflexion, reduction of pain, and restoration of joint mechanics[13].

A football player is likely to get an ankle sprain because the game is so high-impact, with players sprinting off in different directions and jumping. The purpose of this study was to compare the effects of CKCE and MWM on pain reduction, range of motion (ROM), balance, and functional recovery in ankle-sprained football players. Such a comparison would influence their effectiveness on the outcome, and thus help any clinician who is advising on individualized rehabilitation programs for optimal results in pain reduction, joint function restoration, and stability enhancement to improve athletic performance and decrease the possibility of reinjury. The rationale for performing CKCE from a perspective of joint stability and motor control, and MWM in the structure and function of joint mechanics, helps in establishing evidence-based but relevant practices in sports rehabilitation, thus developing the health and performance of football players.

Material and Methods

Study Protocol

A parallel group, assessor-blinded, randomized clinical trial was used to evaluate the effects of CKCE versus MWM in subjects with an ankle sprain.

The study was conducted at the Pakistan Sports Board and Coaching Center, Lahore, Pakistan, between April and Sept 2023.

Ethical approval was obtained from the Ethical Committee of Lincoln University College (Approval number: LUC/CPGS/PGS/20230405/001). The trial was registered prospectively under the Clinical Trial Registry (Registration number: NCT06303141) and has been reported according to the recommendations of the Consolidated Standards of Reporting Trials statement. Trial completion occurred after the data were collected from the final participant. No funding was received for this study.

Participants

Consecutive patients with Grades I or II ankle sprains presenting to the physiotherapy outpatient department were recruited for this trial. A physiotherapist assessed the subjects. A physiotherapist diagnosed the ankle sprain on the basis of the patient's medical history and clinical examination results, which were identified by subtalar and squeeze tests.

The sample size was calculated using G*Power 3.1 software, with an effect size of 0.65, α error probability of 0.05, and power (1–β) of 0.80, yielding a total sample size of 40 participants[17]. The eligibility of the subjects was assessed based on the inclusion and exclusion criteria. Participants between 18 and 30 years of age, participants who had a minimum of one year of active involvement in football, and those who engaged in intensive training regimes comprising 15-20 hours per week were included. Grade 3 ankle sprains, related lower extremity fractures, open ankle wounds, chronic ankle injuries, contraindications to manual therapy, and the withdrawal of informed consent were the exclusion criteria. If a subject's pain increased by 3 points or more on the numerical pain rating scale (NPRS) (Baseline >3 Score) during the first treatment session's intervention, they were also removed from the study.

A written information sheet detailing the study procedure and the advantages and disadvantages of the interventions was provided to the participants. Those who agreed to participate were enrolled, given the option to withdraw at any time, and were requested to sign an informed consent form. Following recruitment, at the first evaluation, a licenced physiotherapist with 8 years of clinical experience and a postgraduate degree in sports physiotherapy provided demographic information. The participants were then randomly and equally allocated to Group A, which received CKCE (n=20), or Group B, which received the MWM (n=20), by the treating therapist. The lottery approach was used to prepare the randomization sequence. Throughout the study, all the subjects were instructed to keep their group identification secret.

Outcome measurement

An 11-point NPRS was used to measure the main outcome, with a higher score indicating more intense pain[14].

The Functional Ankle Instability Index (IdFAI) was used to measure ankle disability; higher scores indicate lower disability[15]. The ankle dorsiflexion and plantar-flexion range, as well as the dynamic balance, were measured via the Star Excursion Test, and higher scores on the SEBT are desirable, as they indicate better balance and stability. The 20-m sprint test was used to calculate lower speeds; lower scores indicated lower speeds[16].

Interventions

Over the course of 4 weeks, each group received 12 treatment sessions. Every intervention was given a one-on-one by a physiotherapist with 8 years of clinical experience treating musculoskeletal diseases, particularly sports injuries and rehabilitation, and formal training in CKCE and MWM. 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 20 minutes at least 3 times a day and to elevate their injured leg on pillows while they slept. The participants were told to start walking again as soon as possible, with the assistance of a walking aid if necessary. 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 5 times and held for 30 seconds each time[17]. In both groups, the exercise regimen started at the conclusion of 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 3 on the NPRS and to resume exercise only if their pain returned to baseline after 5 minutes. If necessary, the workup settings were changed, but the type of exercise remained the same.

Kinesio tape was applied at 30% to 40% tension. After which, in a seated posture with the foot of the injured ankle elevated, the patient was initiated into the ankle balance taping protocol, comprising 4 progressive stages designed to develop joint stability and mobility.

Stage One, Posterior Talar Gliding Taping: to start, this was intended to achieve dorsiflexion, hence the application of tape from the talus, looping both malleoli, and ending at the calcaneus. The ankle was placed in slight dorsiflexion throughout the application for the posterior glide of the talus.

Second Stage, Inversion Taping: slight inversion of the ankle was utilized during the second stage. The tape hold was just proximal to the medial malleolus at 5 cm, directed posteriorly and inferiorly along the malleolus laterally, retaining it across the sole in a lateral-to-medial direction for inversion control.

Third stage, Eversion Taping: in cases of eversion taping, lateral ankle sprain eversion taping, in which there are 2 overlapping strips (50% overlapping), took place to correct the limitation of inversion. The tape began to run at a height of 5 cm above the lateral malleolus, going between the lines posteriorly and inferiorly around the medial malleolus, and ended up cutting across the sole from medial up to lateral.

Fourth Stage, Repeated Posterior Talar Gliding Taping: repetitions of the posterior talar gliding technique completed this stage. They provided further dorsiflexion facilitation, thus finalizing the complete ankle balance taping protocol.

This systematic procedure is beneficial for the maximization of the biomechanical corrections, the enhancement of proprioceptive feedback, and supporting a functional recovery mechanism for ankle instability.

In Group A, patients allocated to the CKCE completed 12 training sessions, divided into 4 weeks. The intervention consisted of 6 closed-kinetic-chain exercises (3 sets, 10 reps each) engaged in CKCE, which emphasizes activities that enhance neuromuscular control, balance, and stability[18]. This program included Calf Raises, Step-Downs, Balance Board Exercises, Mini Squats, Lateral Band Walks, Single-Leg Stance with Reach. Improving proprioceptive awareness and sensorimotor integration in the ankle joint is the goal[19].

Group B participants completed the MWM test for ankle sprains, as detailed by Mulligan, in addition to exercise. While maintaining tibial stability, painless posterior, superior, and lateral stresses were applied to the distal fibula while the patient was in the supine position. To improve comfort, this force was delivered through a pad made of soft material[12]. The individuals were instructed to actively perform ankle plantar flexion and inversion to the greatest extent that they could without pain while this force was sustained. Only after the patient reached a full pain-free range of motion did passive overpressure to plantar flexion and inversion occur. In a single session, a maximum of 3 sets of 8 repetitions were performed.

Statistical analysis

The collected data were analysed via the Statistical Package for the Social Sciences (SPSS) version 25, and the statistical significance level was set at p-value=0.05. Normally distributed data were assessed via the Shapiro-Wilk test, and parametric tests were applied for within and between-groups analyses.

Results

Of the participants, 44 were recruited and randomized into 2 intervention groups (Table 1). Four participants did not receive or start their intervention; therefore, data from 40 participants were included in the analyses. The study's demographic analysis revealed a predominance of male participants, constituting 72.5% (29 individuals), with female participants comprising 27.5% (11 individuals). In terms of body mass index (BMI), most participants, accounting for 90% (36 individuals), fell within the normal range, whereas a smaller proportion, representing 10% (4 individuals), were classified as underweight. Regarding limb dominance, 80% (32 individuals) favoured the right leg as dominant, whereas 20% (8 individuals) favoured the left leg. Analysis of injuries revealed that 62.5% (25 individuals) had injuries to their right leg, whereas 37.5% (15 individuals) had injuries to their left leg.

Table 1 Demographic characteristics

Demographic Characteristics		Frequency	%
Gender	Male	29	72.5
	Female	11	27.5
Body Mass Index	Normal	36	90.0
	Underweight	4	10.0
Dominant leg	Right	32	80.0
	Left	8	20.0
Injured Leg	Right	25	62.5
	Left	15	37.5
	Groups	**M**	**S.D.**
Age (years)	CKCE	21.53	2.939
	MWM	22.05	2.656
Height (feet)	CKCE	5.121	0.227
	MWM	5.056	0.167
Weight (kg)	CKCE	57.529	5.001
	MWM	58.001	3.299

M=mean, S.D.=standard deviation, CKCE=closed-kinetic-chain exercises, MWM=mobilization with movement

Further analysis by group allocation (NMT and MWM) revealed subtle differences. The mean age of the participants in the NMT group was 21.53 years (S.D.=2.939), which was slightly lower than that of the participants in the MWM group (mean age=22.05 years; S.D.=2.656). The mean height measurements were 5.121 feet (S.D.=0.227) for the NMT group and 5.056 feet (S.D.=0.167) for the MWM group. In terms of weight, the NMT group had a mean weight of 57.529 kg. (S.D.=5.001), whereas the MWM group had a mean weight of 58.001 kg (S.D.=3.299). These detailed demographic characteristics provide a comprehensive overview of the study's participant profile, which is essential for interpreting the subsequent findings and implications (Table 1).

The within-group analysis of Group A (closed-chain exercise) revealed significant improvements in all measured outcomes from pre-test to post-test. Pain intensity, assessed using the Numeric Pain Rating Scale (NPRS), decreased from 3.9±0.89 to 2.6±0.83, with a mean difference of 1.3±0.06 (p-value<0.05). Range of motion evaluations showed an increase in dorsiflexion from 18.7±1.44 to 21.3±1.03 (mean difference: 2.6±0.41) and plantarflexion from 38.8±1.7 to 42.5±3.2 (mean difference: 3.6±1.5). Balance, measured using the SEBT, demonstrated a notable improvement, with scores rising from 48.9±7.36 to 60.6±3.9, indicating a mean difference of 11.7±3.46. Functional performance, which was assessed using the impaired functional ankle instability idFAI, improved from 44.7±4.7 to 50.2±5.07; mean difference 5.5±0.37. Thus, it can be said that closed-chain exercises relieve pain, increase range of motion, improve balance, and help achieve functional recovery in people who sustained an ankle sprain. Further support for this is derived from the superior performance observed in the 20-meter sprint test: from a completion time of 3.7±0.22 s to one of 3.14±0.7 s, giving a mean difference of 0.56±0.48. Therefore, closed-chain exercises relieve pain, improve range of motion, improve balance, and help with functional recovery in a person sustaining an ankle sprain (Table 2).

The NPRS demonstrated a significant reduction in pain, decreasing from 4.11±1.10 to 1.5±0.77, with a mean difference of 2.61±0.3 (p-value<0.05). Range of motion showed substantial improvements, with dorsiflexion increasing from 9.84±1.34° to 13.95±1.1° (mean difference: 4.1±0.2°) and plantarflexion increasing from 30.1±2.5° to 41.11±3.0° (mean difference: 11.1±0.5°).

Dynamic balance, assessed using the SEBT, improved significantly, with scores rising from 48.37±7.39 to 59.53 ± 8.19, yielding a mean difference of 11.2±0.8. Functional stability, evaluated using the Identification of IdFAI, also showed marked improvement, with scores increasing from 48.4±7.4 to 60.32±7.8 (mean difference: 11.95±0.43). Performance in the 20-meter sprint test exhibited a minor but measurable improvement, with times decreasing from 3.55±0.17 seconds to 3.31±0.16 seconds, resulting in a mean difference of 0.24±0.01 seconds. The findings, therefore, imply that pain, range of motion, balance, functional stability, and sprint performance were improved significantly in Group B subjects by mobilization along with movement training (Table 3).

Findings from this study comparing the results of the CKCE treatment (Group A) and that of MWM therapy (Group B) are as follows: Between parties, regarding pain relief as measured by the NPRS, Group A followed by a mean difference of 1.3±0.06 and Group B, which had a greater mean difference of 2.61±0.3, showed a

Table 2 group a (closed-chain exercises) pre- and post-test, within-group analysis

Outcome measures	Pre-values	Post-values	Mean difference	p-value
NPRS	3.9± 0.89	2.6±0.83	1.3±0.06	<0.05
Dorsi-flexion	18.7±1.44	21.3±1.03	2.6±0.41	
Planter-flexion	38.8±1.7	42.5±3.2	3.6±1.5	
SEBT	48.9±7.36	60.6±3.9	11.7±3.46	
idFAI	44.7±4.7	50.2±5.07	5.5±0.37	
20m Sprint test	3.7±0.22	3.14±0.17	0.56±0.05	

Pain intensity assessed by NPRS=numerical pain rating scale, dorsi and planter flexion were measured in degrees, SEBT=star excursion balance test, IdFAI=identification of functional ankle instability, and 20 m sprint test was in seconds.

statistically significant difference between the two groups (p-value<0.05). Group A also recorded a mean increase of 2.6±0.41 dorsiflexion and 3.6±1.5 plantarflexion, while Group B had much greater improvements of 4.1±0.2 and 11.1±0.5, respectively. Both groups displayed significant improvements in balance, as measured by the SEBT, with Group A showing an increase of 11.7±3.46 and Group B showing 11.2±0.8, with only a small difference between the two (mean difference of 0.5±2.66). Functional performance, assessed through the idFAI scale, increased by 5.5±0.37 in Group A and 11.95±0.43 in Group B, with a significant mean difference of 6.45±0.06 favoring Group B. Finally, the 20-meter sprint test revealed that Group A had a mean improvement of 0.56±0.05, while Group B showed a smaller mean improvement of 0.24±0.01, with a significant difference of 0.3±0.04. These results highlight that while both interventions were effective, mobilization with movement showed superior outcomes in most parameters, particularly in range of motion and functional performance (Table 4).

Discussion

The present study was aimed at determining the effectiveness of CKCE and MWM in treating ankle sprains among soccer players, especially with a view to pain reduction, increasing ROM, improving balance, and functional outcomes. Upon post-treatment comparison, participants in the CKCE group demonstrated greater overall improvements across several outcome measures compared to the MWM group. Pain intensity, as measured by the NPRS, showed a more pronounced reduction in the CKCE group. Both groups exhibited notable gains in ankle range of motion, with the CKCE group demonstrating greater enhancement in dorsiflexion, while the MWM group

Table 3 group b (mobilization with movement training) pre- and post-test, within-group analysis

Outcome measures	Pre values	Post values	Mean Difference	p-value
NPRS	4.11±1.10	1.5±0.77	2.61±0.3	<0.05
Dorsi-flexion	9.84±1.34	13.95±1.1	4.1±0.2	
Planter-flexion	30.1±2.5	41.11±3.0	11.1±0.5	
SEBT	48.37±7.39	59.53±8.19	11.2±0.8	
IdFAI	48.4±7.4	60.32±7.8	11.95±0.43	
20 m Sprint test	3.55±0.17	3.31±0.16	0.24±0.01	

NPRS=numerical pain rating scale, SEBT=star excursion balance test, IdFAI=identification of functional ankle instability

Table 4 Comparison between group analyses

Outcome measures	Closed Kinetic Chain (Group A)	Mobilization with Movement (Group B)	Mean Difference	p-value
NPRS	1.3±0.06	2.61±0.3	1.31±0.24	<0.05
Dorsi-flexion	2.6±0.41	4.1±0.2	1.5±0.21	
Planter-flexion	3.6±1.5	11.1±0.5	7.5±1.00	
SEBT	11.7±3.46	11.2±0.8	0.5±2.66	
IdFAI	5.5±0.37	11.95±0.43	6.45±0.06	
20 m Sprint test	0.56±0.05	0.24±0.01	0.3±0.04	

NPRS=numerical pain rating scale, SEBT=star excursion balance test, IdFAI=identification of functional ankle instability showed slightly superior improvement in plantarflexion. Balance, assessed through the SEBT, improved markedly in the CKCE group, indicating its stronger effect on postural control. Similarly, functional stability, evaluated using the impaired functional ankle instability scale, improved in both groups, with the CKCE group achieving more substantial gains. Sprint performance also benefitted both interventions; however, the CKCE group achieved a greater reduction in sprint time compared to the MWM group, highlighting its advantage in enhancing speed and agility. In summary, both techniques were effective in pain reduction, improvement of ROM, balance, and functional outcome, but in these regards, CKCE works better in balance and functional stability, while MWM seemed to excel in improving range of motion and pain reduction.

The outcome supported the earlier literature findings regarding the role of MWM in addressing joint restrictions and preparedness for mobilization for biomechanical realignment to bring forth greater improvement in range of motion and neuromuscular coordination[20]. Although CKCE has its benefits in terms of pain relief and sprint performance, due to the focus on joint stability while co-contracting muscles, the intensive performance of the MWM test implied that these gains were melting for broader efficacy against functional impairments and dynamic balance.

Hudson et al. describe the significantly reduced pain in the affected ankle after 9 sessions of CKCE for grade 2 lateral ankle sprains[21]. CKCE is effective in musculoskeletal pain conditions, such as low back and neck pain, chronic musculoskeletal pain in older people, chronic pain after primary total knee arthroplasty[22], and knee osteoarthritis[23]. These exercises are especially good for enhancing the stability of joints for neuromuscular control and improving functional patterns of motor control.

Likewise, the MWM technique has been highly successful in managing pain and improving function in a wide range of musculoskeletal conditions. Cruz-Díaz et al., Marron-Gomez et al., and Vicenzino et al. all showed very substantial improvement post-MWM with respect to ROM and pain relief, especially for ankle sprains and chronic ankle instability[24]. However, Gilbreath et al. mentioned that MWM does not produce remarkable changes in ROM after treatment for chronic ankle sprains, indicating the need to keep in mind the mobilization technique, therapist experience, and treatment duration while determining optimal results[25]. People must carry out multimodal active exercises, including CKCE-MWM, for such conditions in the framework of pain management known as “exercise-induced hypoalgesia”. Both CKCE and MWM have been examined for reducing pain sensitivity, as well as improving ROM, balance, and overall functional capacity[26], most probably by pathways that involve a reduction in nociceptive stimulus sensitivity and the activation of endogenous analgesic pathways[27]. Research conducted by Collins et al. (2004) stated that compression or thermal pain shows poor improvements even after a single session of treatment with CKCE or MWM for similar injuries; it implies that the timing of the treatment, the type of pain, and the intervention dosage become important factors for the final outcome achieved[28].

ROM of the ankle is, as a general rule, not preserved in individuals suffering from ankle instability. This highlights the importance of rehabilitation interventions aimed at restoring ROM and functional capacity. One study strongly recommends that CKCE should be included in rehabilitation protocols for athletes who have suffered ankle sprains, emphasizing their efficacy in improving ROM and functional performance in patients with chronic ankle instability [29]. Indeed, these findings are comparable to those reported by Cruz-Díaz et al., Marron-Gomez et al., and Vicenzino et al., where significant improvements in ROM were also noted following MWM sessions[30]. However, Gilbreath et al. observed no significant changes in ROM after MWM treatment for chronic ankle sprains, highlighting the role of mobilization methods, dosage, and therapist expertise in determining outcomes[31]. Similarly, incorporating CKCE and MWM as complementary approaches may provide synergistic benefits for improving ROM and functional capacity in chronic ankle instability patients.

Functional ankle instability is frequently associated with impaired balance and recurrent sprains, which can significantly impact an individual's functional performance and quality of life. Consistent with prior research, our study demonstrated significant improvements in balance following interventions using both CKCE and MWM[10,12]. These findings align with contemporary literature emphasizing the efficacy of exercise-based interventions in enhancing proprioceptive control and neuromuscular stability in individuals with chronic ankle instability.

CKCE has been widely recognized for its role in improving dynamic stability through muscle co-contraction, joint stabilization, and enhanced proprioception[32]. Exercises that work on the kinetic chain not only strengthen the musculature around the joint, but they also function much better in terms of coordination, which is essential to balance[10]. The SEBT used for this study was said to provide a high level of dynamic balance measure, with significant improvements seen in participants with ankle mobilization. This supports what is said in the literature, where the sensitivity of SEBT was shown to detect balance deficits and improvements after rehabilitation concerning individuals with ankle instability. MWM has also been confirmed to produce both immediate and long-term benefits to balance and functional performance. Research documented the positive effects of MWM for balance amongst older adults; hence, it can play a key role in fall prevention and promoting better functional independence[33]. Again, another study showed that MWM reduces the proprioceptive deficits effectively and enhances the postural control to reduce the risk of recurrent sprains. These improvements in balance, evident with both interventions, support the sensorimotor integration principle, whereby the interaction of mechanical realignment through MWM[34] and neuromuscular activation through CKCE worked to improve both joint stability and dynamic balance[10]. These findings emphasize the rationale for integrating CKCE and MWM into the rehabilitation policy as a multimodal intervention for the multifactorial deficits posed by functional ankle instability.

Subjective sensations of instability are a hallmark feature of individuals with chronic ankle instability, as commonly observed in cases of idFAI. Exercises involving the kinetic chain not only allow for the stabilization of the musculature around the joint, but they also promote much better coordination regarding balance[10], which is essential. The SEBT utilized for this study was said to render a very good measure of dynamic balance, where highly significant improvements were observed with those who received ankle mobilization. The literature alludes to the fact that SEBT is sensitive enough to detect balance deficits and their improvement post-rehabilitation in persons with ankle instability. The immediate and long-lasting benefits of MWM on balance and functional performance have also been established. The positive MWM effect on balance among older adults was studied, and thus can play a major role in fall prevention and better functional independence[35]. MWM was another study-supported technique for proprioceptive deficit reduction and postural improvement to minimize the risk of recurrence due to sprains. Conversely, the improvement in balance with both interventions supports the integration of sensors and motor systems, wherein the mechanical realignment via MWM[36] and the neuromuscular activation via CKCE combine to enhance joint stability and dynamic balance[10]. These findings emphasize the rationale behind the integration into rehabilitation policy for CKCE and MWM as a multi-modal intervention for multifactorial deficits due to functional ankle instability.

The observed improvements underscore the importance of integrating evidence-based multimodal interventions in clinical practice to address the complex interplay of the mechanical, neurological, and functional deficits characteristic of idFAI. These findings add to the growing body of literature advocating for individualized, comprehensive rehabilitation protocols tailored to the needs of patients with chronic ankle instability.

The CKCE programs altogether aim to strengthen muscles, improve coordination, and work on general athletic fitness concerning functional movement patterns and the stabilization of joints. If we rely on research, then it has been found that CKCE programs significantly improve sprint performance, with the findings of an 8-week protocol whereby 20-m sprint times, measurable, were lowered by young athletes[37]. These improvements resulted from the elevation of neuromuscular control, improved proprioception, and increased muscle power, all of which are fundamental in performing explosive-type activities such as sprinting. CKCE exercises, including squats, lunges, and step-ups, involve a number of muscles and help increase intermuscular coordination; thereby, leading to better results in athletics[10]. Conversely, MWM refers to the combination of manual techniques with active movement in the restoration of joint mobility and pain reduction. Although MWM is primarily aimed at increasing the range of motion of the joint and decreasing pain, the effects it may have on sprint speed need to be scrutinized[12]. The literature supports MWM in the enhancement of ankle dorsiflexion and the improvement of joint function, both of which are vital to sprint mechanics[38,39]. MWM may help with sprint times by relieving joint restrictions below, thus promoting the biomechanical alignment of the lower extremity, increasing the transmission of force, and improving stride efficiency[39].

The opposing effects of CKCE and MWM suggest that their joint application may maximize athletic performance, especially in activities where explosive lower limb power integrates with very precise neuromuscular control. This integrated approach adheres to evidence-based practice and supports multidimensional training and rehabilitation approaches intended to optimize functional and athletic results.

The findings of this study highlight the clinical value of both CKCE and MWM in the rehabilitation of athletes with ankle sprains. CKCE is particularly advantageous for improving dynamic balance, functional stability, and sprint performance, making it ideal for return-to-sport conditioning. MWM offers superior benefits for pain reduction and range of motion, supporting its role in the early phases of rehabilitation to restore joint mobility and relieve discomfort. Incorporating both techniques within a multimodal program can address the mechanical, neuromuscular, and functional deficits associated with ankle injuries, thereby optimizing recovery, reducing recurrence risk, and enhancing athletic performance.

Conclusion

Both CKCE and MWM are effective rehabilitation options for football players with ankle sprains. MWM had better results for gaining range of motion, balance, and functional stability, while CKCE was deemed more effective for pain relief and increasing speed performance. This study shows the significance of a multimodal approach in optimizing rehabilitation outcomes for athletes with ankle sprains. This study's generalizability is limited by its small sample size, short follow-up, and reliance on clinical rather than biomechanical assessments. Future research should involve larger, more diverse cohorts, employ advanced tools, such as motion capture and force plate analysis, and assess long-term outcomes. Investigating a combined CKCE–MWM approach may further optimize rehabilitation for sports-related ankle injuries.

Conflict of interest

No conflict of interest.

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