Strengthening exercise and motor control among football players with ankle sprain: A scoping review

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ABSTRACT

Introduction: The ankles and feet of footballers are the most commonly affected areas by acute and chronic injuries, especially sprains. The durability of changes in motor control for the sprained injury strongly suggests that central motor commands have been reorganized and restructured involving the sensorimotor system. Indirectly, providing strength training improves muscular strength and benefits cardiometabolic health, coordination, sensorimotor, and motor performance. Thus, this study aimed to identify the effects of strengthening exercises on motor control among footballers with sprained ankles.

Materials and Methods: This scoping review selected studies published from January 2002 to November 2022. The articles were searched through PubMed Central, BMJ Journal, Science Direct, and Scopus using "motor control", "ankle sprain" and "strengthening exercise" as the keywords. After finding the articles, the information extracted included author, year of publication, country, objective, type of study, and motor control analysis summary. The literature search strategy used Preferred Reporting Items for Systematic Review and a meta-analysis (PRISMA) where studies that are related to strengthening exercise and motor control were selected.

Results: From the initial search, 50 articles were found. After processing, only ten articles were further reviewed. The findings demonstrated strengthening exercises provide changes in neurophysiological parameters with motor performance, improved motor control, strength, balance, pain, and functional movement in footballers with sprained ankles.

Conclusion: This review suggests the application of strengthening exercise interventions not only improves motor control, but strength, balance, pain, and functional performance among footballers with sprained ankles.

KEYWORDS:
Ankle sprain, football, strengthening exercise, motor control, ankle stability

INTRODUCTION

Sprains in the ankle joint are more frequent in physically active people, notably in sports, where they account for at least 14% of all emergency hospital visits.[1] Injury to the lateral ligament complex of the ankle joint results in ankle sprain. Football players' feet and ankles are among the most often affected areas by acute and chronic injuries. Although not life-threatening, the injury frequently negatively impacts participation in sports where the running, jumping, kicking, and changing directions of players are restricted.1 Ankle sprains were among the most common diagnoses during the 2010 FIFA World Cup; and of those, about 50% restricted participation in practice or competition.[2] Additionally, a recent study of an English Premier League (EPL) team found that 20% of injuries for four years were to the foot and ankle, with a resulting mean return to sport time of 54 days.[3]

Ankle sprain causes pain, swelling, and other peripheral damage. The durability of changes in motor control for the sprained limbs supports the idea that central motor commands have been rearranged. As a result, sensory inputs are changed, which prompts the restructuring of the sensorimotor system that results in modifications of movement planning and execution.[4,5] Individuals with chronic ankle sprain will have differences in segmental motor strategies during walking, running, and jump landing, affecting the player's motor control and performance during all activities.

A deficiency in muscular strength may be directly related to the types of ligament injury at the ankle.[6] This will affect the degree of instability and result in different functions in muscle strength, where the muscle that controls the movement will have changes in the axes of motion and produce excessive stress on the surrounding tissues.[7] Dynamic stabilization of the ankle joint will be achieved by the strength of simultaneous activation of muscles on opposite sides of a joint of the muscle surrounding the joint. As a result, due to their inability to properly dissipate these forces in a coordinated manner, athletes who lack or have imbalances in this muscle ability may experience reduced motor control and performance.

Muscle-strengthening exercise, often known as strength/weight/resistance training or exercise, is a voluntary activity that involves using weight machines, exercise bands, handheld weights, or one's body weight.[8]

Muscle-strengthening exercises serve a variety of functions, such as increasing moderate-to-vigorous intensity aerobic physical activity, physical therapy (e.g., injury rehabilitation), conditioning for sports performance, and

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Table I: Table of Evidence

Author (Year)	Study Design	Objective of study	Study Characteristics	Outcome Measure	Groups and Intervention	Results
Duncan et al.[11]	Study Design	To identify the differences of sport performance of motor control after strengthening exercise	Sample size (26). Gender (Male), Age (60-80 years old).	Measure with the International Physical Activity Questionnaire (IPAQ)	Control Group: Maintenance of habit exercise for 12 weeks Experimental Group: Specific Sports Exercise (strength and endurance for 12 weeks (twice a week)	- The experimental group shows improvement in the 30-second chair stand (0.038), 8 feet timed up and go (0.001) but no improvement in strength. - There is a significant difference in the sports performance for the experimental group.
Forte et al.[12]	Experimental Study	To identify the motor control and performance after strengthening exercise.	Sample size (38). Gender (Male), Age (60-65 years old).	Measure with Romberg and Tandem positions on a force platform, maximal isometric handgrip strength, maximal knee flexor, and extensor strength.	Control Group: Gross Motor Skill exercise - Twice sessions per week for 12 weeks Experimental Group: Strengthening exercise Twice sessions per week for 12 weeks	- The experimental group shows improvement in balance, strength, and motor control. - There is a significant difference in motor control and performance in the strengthening exercises group.
Chen et al.[13]	Experimental Study	To identify the effects of integrated motor control strengthening exercise on individuals sport performance.	Sample size (38). Gender (Male), Age (20-60 years old).	Measured with two arm goniometers for AROM and VAS for pain.	Control Group: Conventional Physical Therapy - 5 days per week (week 1), 1 day per week (week 2-4) for 4 weeks Experimental Group: Integrated Motor Control Strengthening exercise - 5 days per week (week 1), 1 day per week (week 2-4) for 4 weeks	- The experimental group shows improvement in balance, strength, and motor control. - There is a significant difference in motor control and performance in the strengthening exercises group.
Ha et al.[14]	Experimental Study	To identify the dynamic balance of individuals with ankle sprain after motor control and strengthening exercises.	Sample size (30). Gender (Male (8), Female (22)), Age (19-25 years old).	Cumberland Ankle Instability Tool (CAIT), ankle's active joint position sense tests (Dualer Digital Inclinometer), Functional Reach Test (FRT)	Control Group: General Ankle Instability Exercise - 40 minutes of general exercises per session Experimental Group: Ankle strengthening exercise applied on the unstable supporting surface 40 minutes of ankle strengthening exercise on a supporting surface per session	- The experimental group had improvement in dynamic balance, static balance, and proprioception sense. - There is a significant difference in dynamic movement, balance, and motor performance ($p<0.05$).
Rabelo et al.[15]	Experimental Study	To identify the effects of pain, performance and function on motor control and strengthening exercise.	To identify the effects of pain, performance and function on motor control and strengthening exercise.	Measure with Numerical Pain Rating Scale (NPRS) and handheld manual dynamometer	Control Group: Strengthening Exercise - 40 min (week 1-3) and 60 minutes (week 4), 3 sessions per week for 4 weeks. Experimental Group: Motor Control Strengthening Exercise - 40 min (week 1-3) and 60 minutes (week 4), 3 sessions per week for 4 weeks.	

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Table I: Table of Evidence

Author (Year)	Study Design	Objective of study	Study Characteristics	Outcome Measure	Groups and Intervention	Results
Smith et al.16	Experimental Study	To identify the differences of strengthening exercise on motor control and performance in individuals with ankle sprain.	Sample size (40). Gender (Male (20), Female (20)), Age (20-25 years old).	Measured with modified ankle instability instrument and using load cell to measure strength and force sense	Control Group: Conventional Physical Therapy exercise for 6 weeks Experimental Group: Specific strengthening exercise (Multiaxial Ankle Exerciser) 3 days per week for 6 weeks	- There is an increase in strength (p=0.01) after 6 weeks of interventions but no relation to proprioception improvement. - There is a significant difference in muscle strength (inversion and eversion) and improved motor control and performance during functional movement.
Horschig et al.17	Single-Case Study	To identify the effects of periodization strengthening exercise on motor control.	Sample size (1). Gender (Male). Age (17 years old).	Measure with Star Excursion Balance Test (SEBT) and lateral step-down excursion test	Single Case Study: Strengthening exercises: 3 weeks 6 sessions, twice a week - Different Repetitive Maximum (RM) – 3RM, 6RM, AND 10RM 2 weeks 5 sessions for 2 weeks - Reduction of resistance for each RM	- It is safely and effectively increasing strength in both healthy populations and individuals recovering from injury during short-term strength training cycles. - There is an improvement in strength and functional movement after periodization strengthening training.
Bleakley et al.18	Experimental Study	To identify the pain, strength, motor performance after strengthening exercise among individuals with ankle sprain.	Sample size (101). Gender (Male), Age (16-65 years old).	Lower Extremity Functional Scale and Sports Ankle Rating Score	Control Group: Conservative Physical Therapy - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks Experimental Group: Ankle Rehabilitation Exercise (Strengthening exercise, neuromuscular training, and sport-specific exercise) - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks - 30 minutes each session with physiotherapy and 4 home-based exercises for 4 weeks	- The experimental group had a favorable overall treatment effect (p=0.0077). - There is a significant difference in pain, strength, and motor performance after accelerated rehabilitation.
Jensen et al.19	Cross-sectional, Correlation Study	To identify the changes of neurophysiological, motor performance an strength with strengthening exercises.	Sample size (24). Gender (Male (13), Female (11)), Age (25-30 years old).	Measured with strength test (1RM), electrophysiological testing, and peripheral nerve stimulation	Measured with strength test (1RM), electrophysiological testing, and peripheral nerve stimulation	- The experimental group shows improved skills performance significantly (p<0.001) - There is a significant correlation between changes in neurophysiological parameters and motor performance for skill learning but not in strength.
Flanagan et al.20	Experimental Study	To identify the effects of strengthening exercise on ankle strength and motor performance.	Sample size (25). Gender (Male), Age (6-12 years old).	Measure with specific activities (Two hands Medicine Ball Put, Standing long jump, and Shuttle Run)	Measure with specific activities (Two hands Medicine Ball Put, Standing long jump, and Shuttle Run)	- Experimental group shows an improvement in motor performance in Two hand Medicine Ball Put, Standing long jump, and Shuttle Run - There is a significant difference in strength and motor performance after strengthening interventions.

strength-related sports proposed that there is a positive effect on motor control and performance of movement after giving strengthening exercises before an injury at the joint.[9] With an injury toward the ankle area, strength training helps increase muscular strength and provides benefits to cardiometabolic health, coordination, sensorimotor, and motor performance.[10] It plays an essential role in preserving the continued independence, physical functions, and maximum performance level of the athletes with an ankle sprain. Hence, does strengthening exercise help improve motor control and performance in athletes with an ankle sprain?

This review investigates the implementation of strengthening exercises on motor control and performance and reports the effects of strengthening training on the individual with an ankle sprain to provide the base knowledge that can guide research to advance in the field and provide the best and most effective treatment.

MATERIALS AND METHODS

This is a scoping review study of articles searched through four electronic databases, PubMed Central, BMJ Journal, Science Direct, and Scopus. The search keywords were "motor control", "ankle sprain", "motor performance" and "strengthening exercise". The article's inclusion criteria are as follows: (1) the study population were patients with ankle sprain; (2) analysing strength training on motor control and performance ; (3) no limitation on the type of study

The exclusion criteria were: (1) Lack of strengthening interventions; (2) Diagnosis other than ankle sprain (3) full text is unavailable, which is only available in the form of abstract, dissertation, conference proceeding, editorials, opinion pieces, review papers, letters, single-case study, short communication, or technical notes.

The extracted information from each article included: author, year of publication, country, objective, type of study, and motor control analysis summary. Screening of articles that are not related to motor control, ankle sprain, and strengthening exercise is excluded and different findings of the articles are considered in order to identify the effects of strengthening exercise on individuals with ankle sprained.

RESULTS

The search process from four databases resulted in 50 articles. After removing duplicates, 40 articles were to be eliminated through the eligibility based on title, abstract, and full text. This selection process finally resulted in ten articles being further reviewed herein. The details of the articles' selection process can be seen in the flow chart in Figure 1.

Among ten articles that are eligible for further review, the types of study found are cross-sectional, literature review, systematic review, and case-control. The objectives are identifying strength training on motor control, motor performance effect after strength training, motor control impairment, and motor control training on motor performance in the ankle sprain population. The data extraction from the reviewed article is demonstrated in Table I.

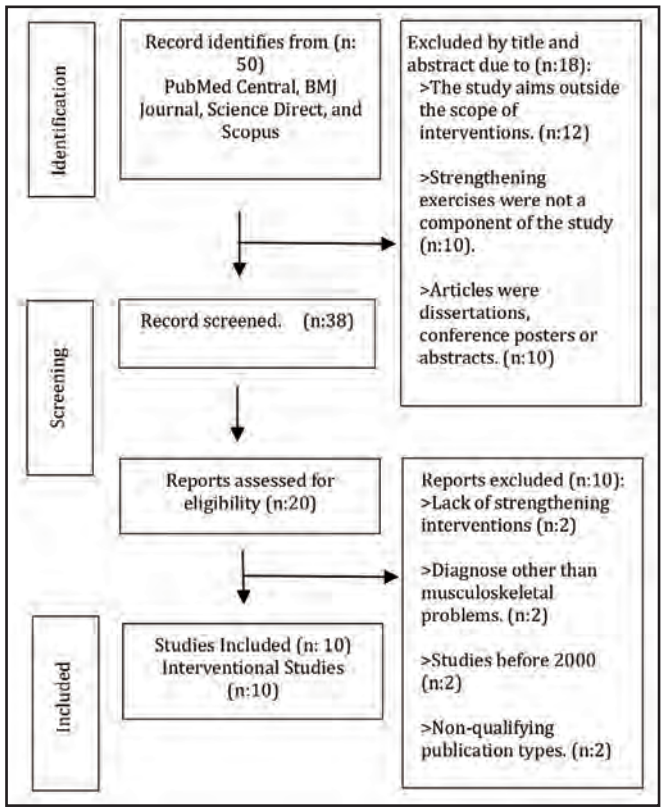

Fig. 1: Article Selection Process Flowchart

DISCUSSION

The findings of this scoping review indicate that the application of strengthening exercise demonstrates potential benefits for improving motor control and performance of functional and specific movement in individuals with an ankle sprain and soft tissue injury. This analysed ten published studies dating from 2002 to 2022, involving a total of 379 individuals aged 8 to 78 years. The strengthening exercise given were varied and different types of strengthening exercises (bodyweight exercise, machine-trained exercises, multiaxial strengthening exercise, specific resistance training, and combination of strengthening training with motor control or visuomotor training) and regime (different types of resistance, repetition maximal and surface) were implemented.

Strengthening exercises were found to improve motor control and performance in individuals with an ankle sprain. Three studies reported that the contribution of strengthening exercise shows a significant difference in motor control and performance compared to the conservative physical therapy treatment in individuals with an ankle sprain or instability.[16,18,20] Combinations of neural factors and hypertrophy through the development of muscular strength help to enhance motor performance and the ability of functional control when individuals perform the movement. The integration of motor control with strengthening training helps to provide feedback to the participants to enhance motor learning by improving temporal muscle activation of motor tasks.[13] Increased muscle activation after sprain or injury consumed higher muscle effort in performing the tasks.

Furthermore, Resistance training helps to reduce muscle activation through neural adaptation or muscle economy and prevents an imbalance of muscle where minimal motor units are required to perform a motor task. Achieving a motor task with smaller muscle activation indicates the participants consumed less muscle effort for the task. It is reported that through strengthening exercises, participants are conscious of controlling the alignment of the joint during movement to increase the performance of the motor movement, but longer training periods for nerve reinnervation and the recruitment of motor units are necessary to produce the significant change.

Injury in the soft tissue structure increases the stress level and causes a deficit in dynamic alignment with weakness of the muscle.[15] Improvement in symptoms by strengthening exercise promotes more significant effects in generating the kinematic changes in the structure. With techniques like the repetition of the task and the movements, motor learning can change how movements are performed. However, the studies identify that a combination of motor control training with strengthening exercise did not provide significant differences compared to the group that only received strengthening training. A slight change in the ankle muscle movement can influence the direction of the movement and the power of the ankle joint and the vector of power in other ankle muscles can show the presence of instability of the ankle joint. Therefore, performing strengthening exercises helps maintain the power balance for coupled activation of normal muscle and stability of the ankle joint.[23]

Implementation of motor control theory in the rehabilitation process shows a great benefit in improving functional motor control and performance. Based on the motor theory, movement regulation is a distributed process resulting from various systems and factors interacting to create and manage movement. It focuses on how the environment and goal-directed actions interact to organize the movement.[21] A previous study conducted with 30 adults with ankle instability shows an increase in motor control after 40 minutes of strengthening exercise on an unstable surface.[14]

The implementation of motor theory (System and Ecological Theory) in this study described the body as a mechanical system with a huge number of joints and muscles that need to be controlled in all movement tasks. The central nervous systems control, organise and coordinate the various degrees of freedom and the effects of gravity in movement through interaction with the environment and task factors. Hence, the contribution of motor control theory in strengthening exercise helps to improve the participant's proprioception, balance, and motor performance.

The effect of strengthening exercise on motor control is doubtable among the elderly population since reductions of muscle strength start between the fourth and fifth decade of life and are more severe when assessed at higher movement velocities. The reduced coactivation of the antagonist's muscle and impairment or dysfunction in a particular structure is caused by the cumulative effects of a wide range of molecular and cellular damage over time and naturally occurring deterioration of several body systems (neuromuscular, cardiovascular, and muscular systems).[22] Even denervation of fibers innervated by alpha motoneurons results from the gradual loss of these neurons in the elderly; two studies on elderly populations with ankle instability show that there are significant differences in motor control and performance after a strengthening exercise.[11,12] A study reported that 12 weeks of training helped in the improvement of dynamic movement and dynamic movement in the participants ($p<0.05$) through augmentations of muscle cross-sectional area, maximum and explosive strength, neuromuscular activation, and muscle power.[12] They show an increase in motor performance during a recreational football game by the participants.

Most of the study should have stated the suitable timing for the application of strengthening exercises after an ankle sprain since it led to pain, loss of function, and atherogenic muscle inhibition through injury of the ligament compartment and microtrauma of the structure. A study conducted on accelerated rehabilitation programs (muscle strengthening, neuromuscular training, and sports-specific functional exercises) on function after acute sport-related ankle sprain shows improvement in participants' strength and motor performance in most of the participant's daily activities.[18] Early reactivation of the ankle musculature, functional movement patterns, and a reduction in the influence of atherogenic muscle inhibition are all recommended in the early stages of injury. Strengthening exercise in the acute stage of ankle sprain also shows improvement in the enhancement of proprioception, which is crucial for ankle rehabilitation and may help improve postural control and movement. The results of the present study show that the biomechanical movement of the ankle joint increase after strengthening exercise since it give feedback about the ankle joint movement where individuals with ankle sprain recognize their motion making the movement of the ankle joint to be in a proper movement and decreasing the imbalance of the muscle to function.[23]

CONCLUSION

The rehabilitation process to improve functional motor control and performance is increasingly becoming focused on exercise through strengthening exercises to gain optimal skills in functional actions. It takes both the capacity to create muscular forces and the capacity for muscle activations to regulate intricate musculoskeletal relationships to restore skilled performance. This review identifies numerous understudied intervention elements that could have a significant impact on motor control and performance with strengthening training for

individuals with an ankle sprain. It emphasizes that strengthening exercises can be implemented in various ranges of ages, populations, and different types of injury. By the application of motor control theory in strengthening exercise, physiotherapy interventions for patients with motor-control deficiencies may benefit from a clinical strategy that acknowledges the impact of the task, the environment, and the individual on the execution of a particular functional movement activity. Separating strength training from achieving improvement of motor control

acknowledges the barriers and strategies that are unique to strength training participation.

More research is required to further investigate the optimal parameters, dosage, and impact of strengthening exercises on motor control for individuals with an ankle sprain to produce a better-strengthening intervention to improve motor control and performance in all populations in their functional activity. With various research focusing on strength training behaviour change specifically, population participation in meeting both strength and motor control guidelines help to improve and optimize population health outcomes in the future.

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ETHICS APPROVAL AND INFORMED CONSENT

This review did not require ethical approval.

CONFLICT OF INTEREST

No conflict of interest.

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AUTHORS CONTRIBUTION

Conceptualization: ZZ, AMT, SAB; data search: AMT; data extraction and editing: AMT, ZZ; methodology: ZZ, AMT, SAB; writing draft: AMT; writing review and editing: ZZ, AMT, SAB.

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