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A Literature Review on Neuromuscular Control Training in Chronic Ankle Instability for the Prevention of Lower Limb Injuries

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Abstract: ***Chronic ankle instability (CAI) is the damage commonly to the lateral ankle ligaments by forced inversion or an outward snapping of the ankle joint relative to the foot. It is one of the most common injuries of lower limb seen in orthopaedic trauma. In most people, only the anterior talo-fibular ligament is affected but, in a minority, this is also can be seen with a combined rupture of the calcaneo-fibular ligament. In most of the cases, conservative treatment leads to fully functional recovery in the majority of people. The term chronic (lateral) ankle instability' is used when the instability i.e., recurrent sprains or giving way persists for longer than six months. It can occur with or without increased mechanical laxity and initially treated conservatively and in most of the cases leads to fully functional recovery in the majority of people. Purpose: To review the literature for finding the effectiveness of neuromuscular control training on preventing lower leg injuries in subject with chronic ankle instability and to review the literature for finding the effectiveness of neuromuscular control on Range of motion, dynamic balance, postural stability, landing phase and on self-reported function in subject with chronic ankle instability. Search method: PubMed, goggle scholar, research gate, science direct, Cochrane from these databases the articles which fulfill the inclusion criteria were taken and reviewed to know the effectiveness of neuromuscular control training on preventing lower leg injuries. Results: Out of 14 articles, 9 articles shows that neuromuscular control training (NMT) is effective as preventive strategy, in that 5 articles show the improvement in landing phases after NMT, 4 article shows improvement in postural control and implementing NMT shows improvement in ROM, ankle joint position sense, earlier leg muscle activation, and self-reported function in subjects with chronic ankle instability. Conclusion: These reviews can be used to demonstrate that neuromuscular control could exhibit a protective strategy for the previously injured ankle and in reduction of other lower limb injury and further injury through improved motor control.***

Keywords: Neuromuscular control training, ankle, chronic ankle instability, previous ankle sprain, lower limb, injury prevention, dynamic and postural control, intervention, self-reported function, AND, OR, IN, WITH.

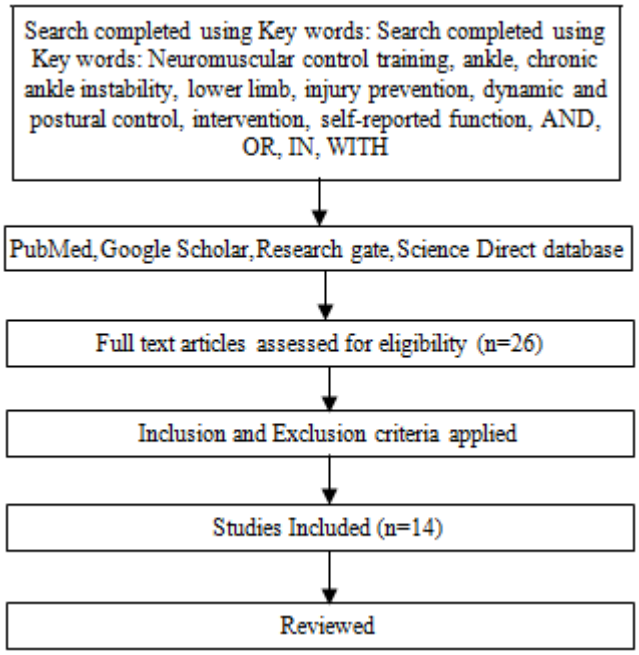
1. Introduction

Chronic ankle instability (CAI) is an encompassing term used to describe the presence of mechanical instability (MI) and functional instability (FI) or both following the occurrence of first ankle sprain[6]. FI is defined as the subjective feeling of instability and is in relation with a proprioceptive and neuromuscular dysfunction while MI is more objective and involves the movement of the ankle joint beyond the physiologic ROM, pathological laxity, arthrokinematics restrictions and degenerative and synovial changes[7.] It is commonly develops following lateral ankle ligament trauma, is a pathological condition characterized bylaxity of the lateral ligaments, repetitive bouts of ankle instability causing the ankle to give way leading to recurrent lateral ankle sprains[1]and residual symptoms, such as pain and instability that last for at least 12 months and is associated with a variety of sensorimotor adaptations, including biomechanical alterations, anterior hypermobility of the talocrural joint and inversion hypermobility of the subtalar joint, decrease ROM (particularly ankle dorsiflexion ROM) [2], decreased strength, altered functional movement patterns, their dynamic balance and gait contributed to recurrent injuries, and postural instability[3]. Individuals with CAI land in a more plantar flexed and inverted position[4]. After the first acute ankle sprain, 40% of people may develop CAI. An updated model of CAI suggests that damaged to the mechanoreceptors located within the lateral ankle ligaments, and possibly the muscle spindles, can negatively alter signal inputs to the central nervous system and consequently influence proprioceptive and neuromuscular control[5.] As a result, reductions in neuromuscular control of the lateral ankle musculature, particularly in the peroneus longus and peroneus brevis, has been identified to be one causative factor that contributes to the recurrent lateral ankle sprain paradigm in individuals that develop CAI[1]. Theprediction of eventual Chronic ankle instability is an inability to complete jumping or landing tasks within 2 weeks of a first-time ankle sprains and poorer dynamic postural control and lower self-reported function 6 months after a first-time ankle sprain[8]

Neuromuscular control exercise (specific stabilization exercise) utilizes principles of neuromotor learning to retrain control of specific muscles and are designed aimed at improving the function of the affected muscles and control of posture and movement patterns, ultimately leading to a reduction in the level of dysfunction, deficits, instability and further injury[9]. It is used to describe a combination of functionally based exercises, including postural stability, proprioceptive, and strength training, as part of a

rehabilitation regimen[3]. NMT programs are effective in improving motor control on tasks requiring dynamic balance and/or a biomechanically desirable movement strategy. Since poor movement quality has been considered a risk factor for lower limb injury can be an effective training method for modifying such risk factors[11]. A key objective of NMT programs is to improve movement competency which can be considered important to the development of fundamental movement skills (FMS) related to motor control and represent the central nervous system's ability to orchestrate coordinated and purposeful movement in relation to the body's interaction with its environment and motor control in the execution of movement may be characterized by the maintenance of posture and balance in the presence of expected and unexpected perturbations[11.]

2. Methodology



Study Selection Data extraction
The data which was collected were tabulated based on the sample size, treatment given, outcome measures used, the results obtained were arranged in chronological order. Inclusion criteria (a) Studies published in English (b) Published between 2010-2022 (c) articles on Neuromuscular training for chronic ankle instability and its effectiveness. (d) Conservative management for chronic ankle instability. Exclusion criteria: (a) Studies not focusing on Chronic ankle instability (b) Case study (c) Other than English Language

Literature Evaluation: The results of the research varied widely. 14 articles were eligible as per the inclusion criteria. The studies were grouped into 9 Randomized control trails, 2 Cross-sectional studies, 1 Comparative, 1 Meta-analytical review, and 1 Cochrane review.

3. Review of Literature

Sl. no	Authors	Years and Journal	Study design	Participants no.	Treatment	Outcome measures	Results
1.	**Chiao-I Lin,** et al[5]	2021, PLOS ONE Journal	Cross-sectional study	26	Muscle activations using EMG	Cumberland Ankle Instability Tool (CAIT) and Foot and Ankle Ability Measure (FAAM)	Leg muscles activated earlier and less bilaterally and Unilateral CAI alters the pattern of the motor control strategy around proximal joints bilaterally.
2.	**Mark D. Williams,** et al[11]	2021, PLOS ONE Journal	Meta-analytical review.	9 studies	Neuromuscular training program, >8 weeks	Y – Balance test, ROM & Star Excursion Balance Test (SEBT)	Moderate, significant effect in favour of NM training programs on motor control, more effective in younger, shorter, and lighter individual and larger effect sizes in males.
3.	**Pi-Yin Huang,** et al[12]	2021, International Journal of Environmental Research and Public	Randomized Controlled Study	30	Plyometric, plyometric integrated, balance training group, Ankle joint	CAIT questionnaire, electro goniometer	Improved ankle joint position sense and neuromuscular control of the ankle plantar flexors during pre-landing phase and single-leg drop landing, reduced adjusting time of the ankle plantar flexor

		Health Article			position sense, integrated electromyography (EMG), 6 weeks		following the impact from drop landing.
4.	**Jarugool Tretriluxana,** et al[13]	2021, Physical therapy in sports	Cross-sectional study	40	Jump-landing task, muscle activation co-contraction.	surface electromyography (EMG), CAIT questionnaire	Detect the differences of neuromuscular control between athletes with and without chronic ankle instability, CAI contributed to altered neuromuscular control during the pre-landing phase, decreased activity of the muscle which may contribute to re-injury mechanisms.
5.	**Mohammad Karimizadeh Ardakani,** et al[4]	2019, Journal of Athletic Training	Randomized controlled clinical trial.	28	Hop Stabilization Training, 3 sessions per week for 6 weeks,	Ankle Instability Instrument, FAAM and Cumberland Ankle Instability Tool	Improved self-reported function, greater ankle dorsiflexion, reduced ground reaction forces, improved jump-landing biomechanics of the ankle, knee, and hip.
6.	**Hatem Jaber,** et al[14]	2018, PLOS ONE Journal	Randomized controlled	48	Muscles activation using EMG, postural control by reach direction	CAIT, Ankle Instability Instrument, SEBT	identify alterations in proximal and distal Neuromuscular control, implementing hip and ankle muscle exercises in the rehabilitation of ankle instability.
7.	**C. Collin Herb,** et al[15]	2018, Journal of Athletic Training	Randomized controlled study	47	Dependent variables of the frontal-and sagittal-plane kinematics and kinetics of the ankle, knee, and hip and the EMG amplitude of 4 lower extremity muscles were assessed during a DVJ	Godin Leisure-Time Exercise Questionnaire score, FAAM-S, Identification of Functional Ankle Instability (IdFAI)	Differences in landing strategies related to continued ankle instability. Kinematic and kinetic changes after ground contact and greater vGRF related to a faulty landing strategy, DVJ task vs gait should be considered for rehabilitation.
8.	**Brent I. Smith,** et al[16]	2017, Journal of Sport Rehabilitation	Randomized controlled	26	Hip strengthening training, 4 weeks	SEBT, Balance Error Scoring System) BESS, FAAM of daily living and sports, AII	Significant improvement in clinical and sport related self-reported outcomes in the hip strengthening training group, beneficial in the management and prevention to improved neuromuscular control, strength, static and dynamic balance of recurrent symptoms.
9.	**João Coito,** et al[17]	2016, Journal of Orthopaedic Research and Therapy	Randomized controlled study.	25	Neuromotor training on postural control and Injury incidence, 8 weeks	Postural Sway Analysis, 4 jump tasks	Improvement of postural control strategies in landing specific tasks, reduction of injury incidence and time-loss after a ligament and muscle injury.
10.	**Shmuel Springer,** et al[18]	2015, Journal of Foot and Ankle Research	Comparative study	14	Postural control and upper limb position sense	Overall Stability Index (OSI), BESS	can use this information of lower limb postural control and upper limb position sense when designing neuromuscular control training programs and potentially reduce the risk of re-injury.
11.	**Mark A. Dundas,** et al[19]	2014, Journal of Sports Sciences	Randomized controlled trial study	33	Single step-down during continuous gait.	CAIT	suggests that a motor strategy of continuous PR enacted before the foot contacts the ground, may be able to adjust the patients neuromuscular control patterns and could exhibit a protective strategy for the previously injured ankle.
12.	**Siavash Dastmanes**	2012, Scholar	randomized controlled	33 males	Core Stabilization	SEBT	Increase in postural control, improve in neuromuscular

	h, et al[20]	Research Library	trial		Training with increase in feed forward and feedback mechanism, lower limb proximal muscle activation, 8 weeks		function and kinetic chain movement, importance of training muscles proximal to the ankle to prevent and reduce reoccurrence.
13.	**Gregory M. Gutierrez,** et al[21]	2012, The American Journal of Sports Medicine	Controlled laboratory study	45	Preparatory and reactive neuromuscular control when landing on a custom-designed ankle supinating device	CAIT	Can increase peroneal activation when necessary to dynamically stabilize the ankle, indicating the potential for training, may deploy a different control strategy after injury to protect the ankle from recurrent injuries, and minimize incidence of injury.
14.	**Jasper S de Vries** et al[22]	2011, The Cochrane Collaboration	Cochrane review	10 studies, in those 4 studies about neuromuscular control	Neuromuscular training (including wobble board and other balance exercises), bidirectional to unidirectional pedaling on a recumbent stationary bicycle for 4 weeks	Ankle Joint Functional Assessment Tool (AJFAT) questionnaire, Foot and Ankle Disability Index (FADI) and the FADI Sport, and modified Karlsson ankle score	Showed a better outcome for neuromuscular training, improve ankle function and short-term effectiveness for subject with chronic ankle instability

4. Results

Out of 14 articles, 9 articles shows that neuromuscular control training is effective as preventive strategy, in that5 articles show the improvement in landing phases after NMT, 4 article shows improvement in postural control and implementing NMT shows improvement in ROM, ankle joint position sense, earlier leg muscle activation, and self-reported function in subjects with chronic ankle instability.

5. Discussion

In a cross-sectional study by *Chiao-I Lin* et al they found that motor control of proximal joints bilaterally was affected by CAI, and that there was altered muscle activation around proximal joints in people with CAI. *Mark D. Williams,* et al found that there is moderate, significant effect in favour of NM training programs on motor control, more effective in younger, shorter, and lighter individual and larger effect sizes in males. *Pi-Yin Huang* in their RCT they found that both isolated plyometric training and integrated balance training were helpful in improving the joint position sense and muscle activation of ankle flexors during the pre-landing phase in athletes with FAI and isolated plyometric training leads to a more rapid stabilization in the ankle plantar flexor during a medial single-leg drop-landing task. In a cross-sectional study by *Jarugool Tretriluxana* et al. they found that in atheletes with CAI the muscles around the ankle joint appear to adapt in order to maintain joint stability via decreased activity of the TA, which is suggestive of muscle activity adaptation. In a RCT conducted by *Mohammad Karimizadeh Ardakani* and company they found that jump landing biomechanics in male basketball players in university changed after a 6 week hop-stabilization program which led them to conclude that the current hop-stabilization program to be an effective and sport specific program that can be used to reduce the risk of lower limb injury. *Hatem Jaber* and company in their Randomized control trial stated that people with CAI had significantly diminished postural control which may be attributed to alteration in the proximal and distal muscle activity such as diminished hip and ankle activity, which also had a negative impact in quality of movement and may lead to prolonged functional impairments. They suggested targeting hip muscles in the conditioning and rehabilitation program for people with CAI. In a RCT done by *C. Colin Herb* they found that there is a difference in landing strategies related to continued ankle instability. Kinematic and kinetic changes after ground contact and greater vGRF related to a faulty landing strategy, DVJ task vs gait should be considered for rehabilitation. *Brent I, Smith* et al in their RCT found that a 4-week hip strengthening protocol improved static and dynamic balance, hip strength and self-reported function related to sports activities in individuals with CAI and an overall improvement in the neuromuscular control of the lower extremity. They suggested that other aspects of the kinetic chain to be incorporated in CAI rehabilitation interventions. In a study by *Joao Coito* et al. found that the application of their 8-week exercise neuromotor program had a positive effect on the postural control and had a reduced incidence of injury in male amateur football players. In a comparative study done by *Shmuel Springer* to investigate the sensorimotor function of different body sites in participants with CAI found that they demonstrated lower

limb postural control and upper limb positions similar to those of healthy controls. In a RCT by *Mark A. Dundas* et al. found that in people with CAI, prior to touchdown there is an increased TA activation which resulted in less plantar flexion, suggestive of a protective strategy for the previously injured foot. *Siavash Dastmanesh* et al found that after 8 weeks of core stabilization training, there were changes in postural control in patients with CAI, which made progress in the neuromuscular function and kinetic chain movement in the lower limb. Their study illustrated the importance of proximal muscles training for the prevention and decreasing the incidence of CAI. *Gregory M. Guierrez* et al. in a study found that people with ankle instability can increase peroneal activation when necessary to dynamically stabilize the ankle, which may be a protective strategy. They also found that dorsiflexion strength is reduced in persons with ankle instability, which may limit their ability to dorsiflex before landing. *Jasper S de Vries* et al in 2011 found that Neuromuscular training showed a better outcome for neuromuscular training, improve ankle function and short-term effectiveness for subject with chronic ankle instability.

6. Conclusion

This literature review analysed the effects of Neuromuscular control on chronic ankle instability. These reviews can be used to demonstrate that Neuromuscular control could exhibit a protective strategy for the previously injured ankle and in reduction of other lower limb injury and further injury through improved motor control. The guidelines given in this review will help us to achieve higher quality results and to also determine the true effectiveness of neuromuscular control training as rehabilitation protocol for chronic ankle instability.

References

[1] Simpson JD, Stewart EM, Turner AJ, Macias DM, Wilson SJ, Chander H, et al. Neuromuscular control in individuals with chronic ankle instability: A comparison of unexpected and expected ankle inversion perturbations during a single leg drop-landing. Hum Mov Sci.2019; 64 (August 2018): 133–41.

[2] Wheeler TJ, Basnett CR, Hanish MJ, Miriovsky DJ, Danielson EL, Barr JB, et al. Fibular taping does not influence ankle dorsiflexion range of motion or balance measures in individuals with chronic ankle instability. J Sci Med Sport.2013 Nov; 16 (6): 488–92.

[3] Lin C-WC, Delahunt E, King E. Neuromuscular Training for Chronic Ankle Instability

[4] Ardakani MK, Wikstrom EA, Minoonejad H, Rajabi R, Sharifnezhad A. Hop-stabilization training and landing biomechanics in athletes with chronic ankle instability: A randomized controlled trial. J Athl Train.2019; 54 (12): 1296–303.

[5] Lin CI, Khajooei M, Engel T, Nair A, Heikkila M, Kaplick H, et al. The effect of chronic ankle instability on muscle activations in lower extremities. PLoS One.2021; 16 (2 February): 1–15.

[6] Spencer Cain M, Ban RJ, Chen YP, Geil MD, Goerger BM, Linens SW. Four-week ankle-rehabilitation programs in adolescent athletes with chronic ankle instability. J Athl Train.2020 Aug 1; 55 (8): 801–10.

[7] David Cruz-Diaz, Rafael Lomas Vega, Maria Catalina Osuna-perez, Fidel Hita-Contreras and Antonio Martinez-Amat (2015). Effects of joint mobilization on Chronic ankle instability: a randomized controlled trial, Disability and rehabilitation, 37: 7, 601-610.

[8] Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Recovery from a First-Time Lateral Ankle Sprain, and the Predictors of Chronic Ankle Instability. Am J Sports Med.2016 Apr 1; 44 (4): 995–1003.

[9] Costa LOP, Maher CG, Latimer J, Hodges PW, Herbert RD, Refshauge KM, et al. Motor Control Exercise for Chronic Low Back Pain: A Randomized Placebo-Controlled Trial.2009.

[10] Macedo LG, Latimer J, Maher CG, Hodges PW, Mcauley JH, Nicholas MK, et al. Effect of Motor Control Exercises Versus Graded Activity in Patients with Chronic Nonspecific Low Back Pain: A Randomized Controlled Trial.2012.

[11] Williams MD, Ramirez-Campillo R, Chaabene H, Moran J. Neuromuscular Training and Motor Control in Youth Athletes: A Meta-Analysis. Percept Mot Skills.2021 Oct 1; 128 (5): 1975–97.

[12] Huang PY, Jankaew A, Lin CF. Effects of plyometric and balance training on neuromuscular control of recreational athletes with functional ankle instability: A randomized controlled laboratory study. Int J Environ Res Public Health.2021; 18 (10).

[13] Tretriluxana J, Nanbancha A, Sinsurin K, Limroongreungrat W, Wang HK. Neuromuscular control of the ankle during pre-landing in athletes with chronic ankle instability: Insights from statistical parametric mapping and muscle co-contraction analysis. PhysTher Sport.2021; 47: 46–52.

[14] Jaber H, Lohman E, Daher N, Bains G, Nagaraj A, Mayekar P, et al. Neuromuscular control of ankle and hip during performance of the star excursion balance test in subjects with and without chronic ankle instability. PLoS One.2018; 13 (8): 1–16.

[15] Collin Herb C, Grossman K, Feger MA, Donovan L, Hertel J. Lower extremity biomechanics during a drop-vertical jump in participants with or without chronic ankle instability. J Athl Train.2018; 53 (4): 364–71.

[16] Strength H, Docherty CL, Curtis D. Effects of Hip Strengthening on Neuromuscular Control, Hip Strength, and Self-Reported Functional Deficits in Individuals With Chronic Ankle Instability. J Sport Rehabil.2017.

[17] Coito J, Oliveira R, Melo F (2016) Effects of a NeuromotorReeducation Program on Postural Control and Musculoskeletal Injury Incidence of Amateur Football Players. J Orthop Res Ther 2016: 27-33.

[18] Springer S, Gottlieb U, Moran U, Verhovsky G, Yanovich R. The correlation between postural control and upper limb position sense in people with chronic ankle instability. J Foot Ankle Res.2015; 8 (1): 1–7.

[19] Dundas MA, Gutierrez GM, Pozzi F. Neuromuscular control during stepping down in continuous gait in individuals with and without ankle instability. (December 2014): 37–41.

[20] Dastmanesh S, Shojaedin SS, Eskandari E. ABR-2012-3-8-3926-3930 The Effects of Core Stabilization

Training on Postural Control of subjects with Chronic Ankle Instability.2014; (December).
[21] Gutierrez GM, Knight CA, Swanik CB, Royer T, Manal K, Caulfield B, et al. The American Journal of Sports Medicine Examining Neuromuscular Control During Landings on a Supinating Platform in Persons with and Without Ankle Instability.2012;
[22] De Vries JS, Krips R, Sierevelt IN, Blankevoort L. Interventions for treating chronic ankle instability. Cochrane Database Syst Rev.2006; (4).