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Original Research Article

A review of the Ankle Joint Movement in People with Ankle Instability

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ABSTRACT

Introduction: Chronic ankle instability is usually caused by recurrent ankle sprains. It is estimated that about 70% of people with the first external ankle sprain develop chronic ankle instability. The purpose of this article is to review the background of studies on the variability of ankle joint movement pattern and neuromuscular control strategies in individuals with functional ankle instability. **Methods:** Articles in reputable databases such as ProQuest, Pubmed Medline, Science Direct were searched for words, functional ankle instability, variability, gait, and neuromuscular control, from 1960 to the end of 2021 **Results:** Based on the results, issues such as ankle joint movement pattern in healthy individuals and people with chronic ankle instability, closed-loop mechanism [reactive], open-loop mechanism [pre-movement] and their role in complete ankle joint instability Were explained. **Conclusion:** The results presented in the studies that have been done so far on identifying the mechanisms underlying the functional instability of the ankle show the difference between nonlinear and linear dynamic view. In fact, from the point of view of linear dynamics, the results of studies indicate the fact that the ankle in the frontal plane has more displacement in people with functional instability. While from a nonlinear dynamic's perspective, studies have shown that people with functional ankle instability have less movement in the frontal lobe than healthy individuals.

Keyword: Ankle joint, functional instability, ligament, variability

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Introduction

Chronic ankle instability is usually caused by recurrent ankle sprains. It is estimated that about 70% of people with the first external ankle sprain develop chronic ankle instability. People with chronic ankle instability often suffer from ankle pain, instability, or a feeling of emptiness. Chronic ankle instability is divided into two general branches: mechanical instability and functional instability [1-3]. Mechanical instability results from inadequate joint mechanics and is actually related to measurable joint relaxation and joint kinematic constraints and synovial changes [4-6].

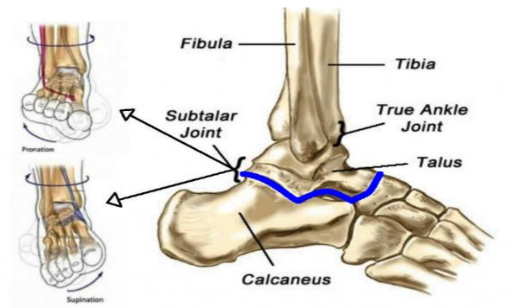

Fig 1: View of ankle instability

Functional instability is defined as a feeling of instability without joint relaxation, meaning that people with functional ankle instability may experience long-term instability with a feeling of mental ankle emptying, but there is no ligament relaxation in the ankle joint [7-9]. This condition is often associated with damage to the sense of depth, neuromuscular control, fluctuations in posture, balance, and strength. Freeman et al. Ankle experience the mental feeling of empty ankle repeatedly, the person is suffering from functional instability of the ankle [10]. Researchers believe that although functional and mechanical instability are interrelated, it is important that the two can exist independently in an individual. One of the most important findings in people with functional ankle instability is the joint kinematic change in the gait oscillation phase. For example, people with functional ankle instability have more inversion in the foot than healthy people before the heel hits the ground, so in general it can be said that changes in joint kinematics can be one of the possible reasons for ankle sprain recurrence [11-13]. But it is not able to fully reveal the mechanisms underlying chronic ankle instability [14-16]. For this reason, researchers today have suggested that inappropriate changes in neuromuscular control play an important role in the development of chronic [functional] ankle instability [17-19]. The purpose of this article is to review the background of studies on the variability of ankle joint movement pattern and neuromuscular control strategies in individuals with functional ankle instability [20].

Methods

Articles in reputable databases such as ProQuest, Pubmed Medline, Science Direct were searched for words, functional ankle instability, variability, gait, and neuromuscular control, from 1960 to the end of 2021. In this review article, in the first step, all articles that contained at least three keywords of the mentioned keywords were reviewed. In the second step, according to the relevance of the selected articles, the closest articles were thematically preserved and the rest were excluded from the study. In the third step, conference papers, papers on a non-human sample, papers on human specimens without checking for mechanical instability in research specimens, and papers with similar results were excluded from the study process. That were directly related to the main topic were examined.

Results and Discussion

The kinematics of the ankle joint have been studied by many researchers. Studies have shown that kinematic events of the ankle joint during walking in the posture phase and oscillation in a healthy person in such a way that in the initial stage of impact with the foot, the ankle has an average of 5 degrees of plantar reflection and 5 degrees of inversion. While the Talocrural Joint has plantar flexion, it has a sprained joint to absorb pronation shock. Exactly before the sole of the foot is on the ground until after the heel joint is lifted, the dorsiflexion has a dorsiflexion. Due to the fact that the foot is fixed on the ground, the dorsiflexion is created by a large movement on the snatch. Most dorsiflexion occurs when the center of gravity of the body is in the anterior part of the support surface [21-23].

Simultaneously with dorsiflexion, the sprained joint of the pronation and the hind foot have an urgency, in fact, most pronation occurs before the most dorsiflexion. The most pronounced pronation is to indicate the beginning of the propulsion stage in the foot. As the heel begins to rise, the ankle begins to plantar flexion and supination. With plantar flexion and supination, the plantar fascia is stretched and stabilizes the transverse joint through the windlass mechanism. In order to prepare for lifting the toes, he has taken a hard position to be able to transmit force to the upper joints. Dorsey ankle flexion and pronation occur during the flight phase, while there is a difference in the kinematics of ankle joint movement while walking in people with chronic ankle instability compared to healthy individuals. The most common change in ankle joint kinematics has been reported in the frontal plane and in the oscillating phase. Many researchers have shown that foot inversion before the heel hits the ground is higher in people with chronic ankle instability than in healthy people, and generally confirmed more ankle displacement in the frontal plane [24-26]. Damage to the Calcaneofibular Ligament is one of the reasons mentioned for this event. In fact, this ligament restricts inversion and movement in the frontal plane, which is often damaged in the external ankle sprain. More inversion when the heel hits the ground creates additional lateral forces that the protective reflex is not able to respond to this change of position in time, so in people with chronic ankle instability where there is a change in the position of the ankle in the heel to the ground, the pattern Joint stress will be different than in healthy people [27].

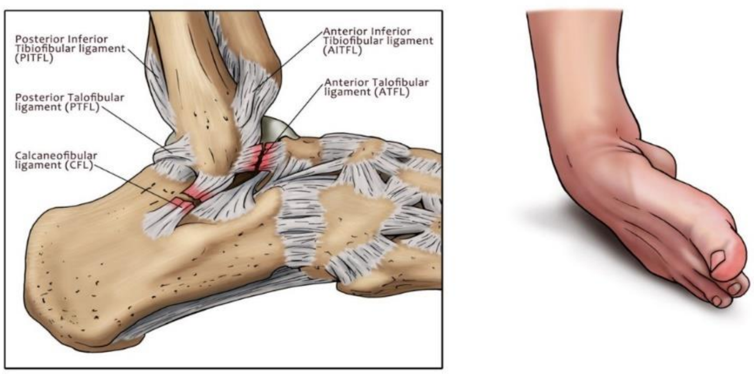

Fig 2: Ankle ligaments affecting ankle instability

The researchers examined the kinematics of the ankle while walking on the frontal plate in people with chronic ankle instability and presented the opposite results of the study. To healthy people. The difference observed in the research results can be explained by the fact that the present study from a nonlinear dynamics perspective described the characteristics of people with chronic ankle instability, unlike previous studies that chose a linear perspective for the study [28-30]. According to the research reported above, both linearly and nonlinearly, the true mechanism of chronic ankle instability after the first aspirin has not yet been generally identified, although foot and ankle mechanics play a very important role in the occurrence of this injury. Plays. Recently, it has been suggested that not only does the kinematics of movement change in people with chronic ankle instability, but more importantly, neuromuscular control plays an important role in perpetuating the return of instability [31-33]. Neuromuscular control is defined as the interaction between the nervous and musculoskeletal systems to produce an appropriate response to stimulation. Changes in motor control programs play an important role in the development of functional instability, these changes indicate changes in the spinal cord and cortex that cause defects in postural control. During the activity, dynamic and static barriers work together, this cooperation through Open-Loop and Closed-Loop and voluntary mechanisms in order to maintain the correct joint direction and stability in response to the forces imposed on the joint [34].

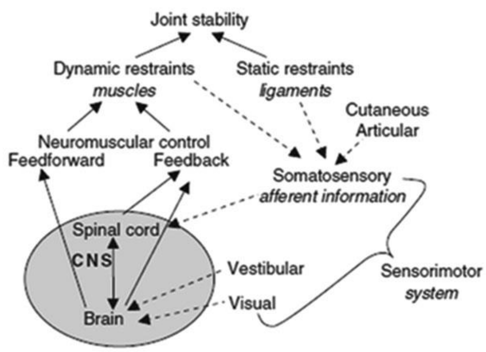

Fig 3: Neuromuscular control in the ankle joint

There are two possible theories to describe the development of ankle instability: a change in the closed loop versus a change in the control of the open loop neuromuscular. In general, open-loop control involves predicting muscle activity [in other words, before stimulation] to prepare a person for stimulation. In the ankle joint, this loop involves activating the muscles around the joint before stimulation [descent] to control the dynamic stability of the joint. Conversely, closed-loop control at the ankle joint is based on a reflex arc, meaning that when the ankle is in an inversion position too much, the sensory receptors on the external ligament send a message to the spinal cord, followed by a message. Gamma is sent to the motor neuron in the muscle spindles of the thin muscles to eventually cause the thin muscles to contract to prevent excessive stretching [35-37]. Invertebrate ankle sprain is the result of two related phenomena. First, an inversion rotation consisting of inversion and plantarflexion movements occurs in the tibial joint, and then inverted joint inversion occurs so that the center of pressure between the foot and the ground surface shifts into the axial joint. The first electrophysiological reaction following sudden ankle inversion is the response to electrical activity of the peroneal muscles, which occurs with a delay time of 49 to 90 milliseconds. Although the true nature of ankle functional instability has not yet been determined, there is evidence of musculoskeletal disorders. When discussing functional ankle instability, researchers suggested the idea of Articular Deafferentation as the mechanism of this injury. They suggested that damage to the articulation structure of the joint after external ankle sphincter creates a vacuum in the sensory feedback to the central nervous system, which gives rise to a feeling of mental emptiness in these individuals. It is inferred that reactive responses [closed-loop control] can negatively affect individuals with profound sensory impairment. In particular, delayed response time in the ankle overture muscles to an Unexpected Perturbation may be a way of detecting a disorder of the closed-loop neuromuscular control system [38-40]. Kondradsen & Raven's 1990 study was one of the first studies to examine the timing of thinning muscle reactions in people with ankle instability. In this study, the time of thinning muscle reaction was defined as the time difference between the onset of perturbation and the onset of thinning muscle activity. Their findings supported the theory of joint detoxification in that in their study, people with ankle instability had delayed thin muscle reaction time; Most researchers found that people with chronic ankle instability had delayed reaction time in the thin reed muscles. In one study, the reaction time of the thin reed muscles in response to an external disturbance was tested on patients with ankle instability in one limb. Healthy feet were considered as control. The results of this study showed that there is no significant difference between the two organs in terms of reaction time of thin reed muscles. Other researchers have shown that in addition to an injured foot, there is a defect in nerve control in a healthy foot [41]. Therefore, considering a healthy foot as a control requires more research. On the other hand, in one study, the hypothesis of differences in the reaction time of the thin reed muscles in different degrees of movement in the frontal plane was tested in people with ankle instability, but no significant differences were found between the injured and healthy groups [42].

In general, there was no final consensus that delayed onset of thin reed muscle activity following an external disturbance was a sign of ankle instability. In their meta-analysis study, the researchers reported that the differences observed in the research results were related to methods for assessing the reaction time of thinning muscles. Some researchers have reported the possible causes of these discrepancies in the results of various studies to differ in similar criteria in the selection of people with ankle instability and different methodologies [43]. In addition, the generalization of the results of these studies to functional activities is questionable because the reflective responses measured in these studies have been calculated under static conditions and during fully controlled perturbation. In one study, researchers compared reflex responses to sudden ankle inversion while standing and walking, and concluded that reaction time while walking was shorter than standing. They hypothesized that this was due to increased muscle activity and changes in spindle sensitivity during walking. Another researcher examined landing on rotating surfaces without rotating inwards and did not observe a statistically significant difference in the time of muscle activity between landing on two surfaces, but the intensity of the thin muscle response when landing on a rotating surface No further rotation was reported. These results confirm the role of tensile reflective responses in creating dynamic joint stability after landing, so that after foot contact with the ground, stretching mechanisms along with pre-planned muscle activity play a role in maintaining joint stability and separating these two types of activity. It is difficult. Various studies have been performed to evaluate the reflex response following ankle sprains, but in one study, researchers concluded that the reflex response alone was too slow to prevent ankle sprain. They stated that the first active urethral activity occurs 176 thousandths of a second after the onset of perturbation plate motion [including muscle reaction time, electromechanical delay, and torque generation time] while the amount of rotation required to damage the external ankle ligaments [approx. 40 degrees] about 80 thousandths of a second after the start of the movement of the turbulence plate. Thus, despite the relatively long delay in reed muscle response in people with ankle instability, all reflex responses alone are very slow to protect the ankle following a sudden ingestion and proactive activity [open-loop control]. Should be taken to prevent ankle sprains. Therefore, before any medical conclusions, more scientific work is needed to determine the role of closed loop control in the dynamic stability of the ankle joint, especially in people with ankle instability. In fact, closed loop control may not be the most important factor in maintaining joint stability [44]. In various texts, the study of contact force during walking and landing has attracted a lot of attention. It is hypothesized that a defect in the proper design of neuromuscular strategy to reduce contact force may lead to musculoskeletal injuries. During walking the ankle muscles before and during the initial part of the posture stage is active to help stabilize the foot and ankle. It has been suggested that muscle spindle sensitivity may increase during the initial stage of gait posture, which may lead to increased joint stiffness due to Alpha-Gama Coactivation [45].

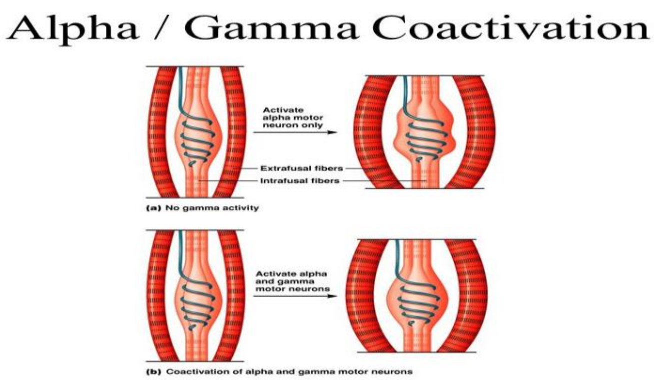

Fig 4: Coactivation Alpha-Gama

Muscle activity is important to maintain proper joint stiffness. Improper levels of joint stiffness may not provide adequate acceleration for the joint to land safely, while increased joint stiffness may be detrimental to muscle, tendon, and bone structures, so these structures absorb more load. Proper neuromuscular control during jumping and landing requires adjusting the temporal characteristics and range of activity of the muscles, so that the joint stiffness against the characteristics applied by the motor task, including the height of the jump and the stiffness of the landing surface, must be properly adjusted. After the foot touches the ground, the closed-loop mechanisms are activated and the pre-programmed movement pattern is adjusted based on the sensory feedback obtained from the kinetic chain. As mentioned, without muscle pre-activity, the tensile reflex mechanisms cannot control joint rotations due to delayed execution. During the landing phase, there are a number of neuromuscular events that prepare a person for a collision with the ground, including muscle activity before the foot touches the ground, called preparatory or open-loop activity [46]. Recent studies have examined the control of the ankle open ring in people with instability. The researchers claimed that during landing, the amount of thin muscle activity before the foot hit the ground in people with ankle instability decreased compared to the healthy group. The researchers hypothesized that due to the need for stiffness during landing, decreased muscle activity was a hallmark of the internal model in people with ankle instability, and that the phenomenon of impaired joint afferent delivery may be due to long-term inhibition due to profound sensory impairment. On the other hand, changes in thin muscle activity may be the result of local damage to a muscle or nerve following primary injury. Regardless of the cause of this inappropriate neuromuscular activity, dysregulation of the thinning muscles increases the risk of injury in people with ankle instability. The timing of the maximum reaction force coincides with the vulnerability of the ankle joint, as most external ankle sprains occur shortly thereafter. Therefore, placing people with instability in this period when the vulnerability is greater, will increase the likelihood of injury [47].

Conclusion

The results presented in the studies that have been done so far on identifying the mechanisms underlying the functional instability of the ankle show the difference between nonlinear and linear dynamic view. In fact, from the point of view of linear dynamics, the results of studies indicate the fact that the ankle in the frontal plane has more displacement in people with functional instability. While from a nonlinear dynamic's perspective, studies have shown that people with functional ankle instability have less movement in the frontal lobe than healthy individuals. Thus, both linearly and nonlinearly, the true mechanism of ankle functional instability after the first aspirin has not yet been fully identified, although foot and ankle mechanics play a very important role in the occurrence of this injury. Recently, it has been suggested that not only does the kinematics of movement change in people with chronic ankle instability, but more importantly, neuromuscular control plays an important role in perpetuating the return of instability. In fact, there is a change in movement control programs [closed and open loop mechanisms] that these changes indicate changes in the spinal and cortical levels that eventually lead to defects in postural control. However, which of the neuromuscular control mechanisms [closed and open loops] play a more important role in the development of instability has not been clearly studied. Therefore, more research is needed to examine neuromuscular control strategies in people with ankle instability.

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