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Relationship between Sensory Perception, Proprioception of Foot and Ankle and Balance among Athletic and Non-Athletic Healthy Subjects

MASTER THESIS

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated26/01/2021 and numbered 2021/01-65.

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

03/01/2021

Amani Altaee

DEDICATION

I dedicate this thesis to my beloved parents who continually provide their moral, spiritual, emotional, and financial support. To all my sisters and brothers for lavishing me with their affection and love.

To Prof. Dr. Rasmi Muammer who shared his knowledge and advice to finish this work. And to my friends who shared their words of advice and encouragement.

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LIST OF SYMBOLS AND ABBREVIATIONS

ROM	Range of motion
CNS	Central Nervous System
PNS	Peripheral Nervous System
PAG	Periaqueductal Grey Matter
TNS	Transcutaneous Nerve Stimulation
COM	Center of Mass
COG	Center f Gravity
BOS	Base of Support
POMC	Protein proopiomelanocortin
MSH	Alpha-melanocyte stimulating hormone
ACTH	Adrenocorticotropin
GTO	Golgi Tendon Organs
JPS	Joint Position Sense
TTDPM	Threshold to Detection of Passive Motion
ART	Angle Reproduction Test
CE	Constant Error
VE	Variable Error
AE	Absolute Error
AAE	Absolute Angle Error
1^{st} MTPJ	First Metatarsophalangeal
5^{th} MTPJ	Fifth Metatarsophalangeal
DF	Dorsiflexion
PF	Planterflexion
BMI	Body mass index
SEBT	Star excursion balance test

AntR	Anterior right
AntLatR	Anterolateral right
AntMedR	Anteromedial right
MedR	Medial right
LatR	Lateral right
PostR	Posterior right
PostLatR	Posterolateral right
PostMedR	Posteromedial right
AntL	Anterior left
AntLatL	Anterolateral left
AntMedL	Anteromedial left
MedL	Medial left
LatL	Lateral left
PostL	Posterior left
PostLatL	Posterolateral left
PostMedL	Posteromedial left

ABSTRACT

Amani A. (2021) Relationship between Sensory Perception, Proprioception of Foot and Ankle, and Balance among Athletic and Non-Athletic Healthy Subjects. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc thesis, Istanbul.

Exercise is considered as one of the multidisciplinary additions to treatment programs, and it is recommended in the guidelines of many treatment protocols for the improvement of many impaired physical functions.Pain perception is known to be sensitive to various processes, therefore the amount and nature of the pain are not exclusively driven by the noxious input itself, but it can be influenced by psychological, mental, physiological and physical reasons. Proprioception is the feedback that is driven from sensation and recognization of external features and contributes to conscious muscle sensation, postural equilibrium, and joint stability. While balance can be defined statically as the ability to maintain a base of support with minimal movement and dynamically as the ability to perform a task while maintaining a stable position. The purpose of this study is to determine how can regular exercising affect pain perception, proprioception, and balance among healthy young subjects and to identify the nature of the correlation between those factors. 42 healthy participants were included in this study (21 athletes and 21 non-athletes). An algometer (push-pull baseline dolorimeter 66LB/30KG) was used for the evaluation of pain threshold and pain tolerance ratings, for proprioception repositioning accuracy was quantified through the active angle reproduction test (AART) for first, fifth metatarsals and ankle joints, and the dynamic balance was assessed by star excursion balance test (SEBT), while static balance tested by a single-leg standing test (SLST). The findings showed significant diffirences between athletes and non athletes in pain perception, proprioception and dynamic balance($p<0.05$) so they are affected with regular exercise. While static balance showed not to be affected with regular exercise as there was no significant difference between groups ($p>0.05$). Pain perception, proprioception and dynamic balance are influenced by gender ($p<0.05$), while static balance is not affected by gender ($p>0.05$). A positive meaningful relationship was found only between Body mass index and pain perception among athletes group. Pearson Correlation test showed that there is no meaningful relationship between any of pain perception, proprioception or balance in both

groups. İn a conclucion regular participation to different types of sports showed to affect on pain perception, propprioception, and dynmic balance□ but not static balance. An influence of gender on pain perception proprioception and dynamic balance but not static balance was releved. Also there was no meaningful correlational relationship between any of the evaluated variables.
Keywords: Joint Position Sense, Pain Perception, Balance,

ÖZET

Amani A. (2021) Atletik ve Atletik Olmayan Sağlıklı Denekler Arasında Duyusal Algı, Ayak ve Ayak Bileği Propriyosepsiyonu ve Denge Arasındaki İlişki. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans tezi, İstanbul.

Egzersiz, tedavi programlarına multidisipliner eklemelerden biri olarak kabul edilir ve birçok bozulmuş fiziksel fonksiyonun iyileştirilmesi için çok sayıda tedavi kılavuzunda önerilmektedir. Ağrı algısının çeşitli süreçlere duyarlı olduğu bilinmektedir, bu nedenle ağrının miktarı ve doğası yalnızca zararlı girdinin kendisi tarafından yönlendirilmez, ancak psikolojik, zihinsel, fizyolojik ve fiziksel nedenlerden etkilenebilir. Propriosepsiyon, bilinçli kas duyusuna, postüral dengeye ve eklem stabilitesine katkıda bulunan duyusal geri bildirimdir ve ciltte, kaslarda, tendonlarda, bağlarda ve eklem kapsüllerinde bulunan propriyoseptörler aracılığıyla gerçekleştirilir. Denge, statik olarak minimum hareketle bir destek tabanını koruma yeteneği ve dinamik olarak sabit bir pozisyonu korurken bir görevi yerine getirme yeteneği olarak tanımlanabilir. Bu çalışmanın amacı, sağlıklı genç denekler arasında düzenli egzersiz yapmanın ağrı algısını, propriyosepsiyonu ve dengeyi nasıl etkileyebileceğini belirlemek ve bu faktörler arasındaki ilişkinin doğasını belirlemektir. Bu çalışmaya 42 sağlıklı katılımcı dahil edildi (21 sporcu ve 21 sporcu olmayan). Ağrı eşiği ve ağrı tolerans derecelendirmelerinin değerlendirilmesi için bir algometre (push-pull bazal dolorimetre 66LB / 30KG) kullanıldı, propriosepsiyon yeniden konumlandırma doğruluğu, birinci, beşinci metatarsallar ve ayak bileği eklemleri için aktif açı üreme testi (AART) ile ölçüldü ve dinamik denge, yıldız sapma dengesi testi (SEBT) ile değerlendirilirken, statik denge tek ayak ayakta testi (SLST) ile test edildi. Bulgular, sporcular ve atlet olmayanlar arasında ağrı algılama, propriyosepsiyon ve dinamik denge ($p < 0.05$) açısından önemli farklılıklar gösterdi, bu nedenle düzenli egzersizden etkilendiler. Statik denge, gruplar arasında anlamlı fark olmadığı için düzenli egzersizden etkilenmediğini gösterirken ($p > 0.05$). Ağrı algısı, propriyosepsiyon ve dinamik denge cinsiyetten etkilenirken ($p < 0.05$), statik denge cinsiyetten etkilenmez ($p > 0.05$). Sporcu grupları arasında sadece vücut kitle indeksi ile ağrı algısı arasında pozitif yönde anlamlı bir ilişki bulundu. Pearson Korelasyon testi her iki grupta da ağrı algısı, propriyosepsiyon veya denge arasında anlamlı bir ilişki olmadığını gösterdi.Sonuç olarak, farklı spor türlerine düzenli katılım, ağrı algısı, propriyosepsiyon ve dinsel denge üzerinde etkili olduğunu, ancak statik dengeyi etkilemediğini göstermiştir. Cinsiyetin ağrı algılama propriyosepsiyonu ve dinamik denge üzerindeki etkisi ortaya çıktı, ancak statik denge değil. Ayrıca değerlendirilen değişkenlerin hiçbiri arasında anlamlı bir korelasyonel ilişki yoktu.

Anahtar Kelimeler: Eklem Pozisyon Hissi, Ağrı Algısı, Denge,

1. INTRODUCTION AND PURPOSE

When talking about pain perception and its relation to people's physical activity level, it is common to find a meaningful difference between athletes and normally active persons. And those significant differences are mainly based on the fact that athletes are able to continue their exercise in face of severe injury and pain. By researching previous studies we found that physical activity may influence pain perception in one way or another and concluded that athletes generally have higher pain thresholds and higher pain tolerance ratings than non-athletes. [1]

Over and above, pain is known to be the first physical natural defensive mechanization against any damage, injury, or overuse which makes it an influential diagnostic feature. Subsequently, deeper information about how physical activity is affecting pain perception will influence the medical care and the treatment protocols that are follwed for pain patients generally, and the rehabilitation process for athletes and sports injuries particularly. [2]

Physical activity revealed to produce an acute direct effect in addition to a long-term effect on pain preception. The way how physical activity affects on pain perception and pain modualation that occurs during and directly after exercise is known as (acute exercies induced analgesia) which must be well recognized and differentiated from the general modulation of pain perception that occurs at rest.[3]

With regard to acute effects of physial activity, there is cosistent evidence that following a frenzy of intense physical exercise, pain perception showed to be diminshed for limited time period. Moreover studies regarding pain perception in athletes at rest have proverd different results. An elevation of both pain tolerance and pain threshold have been noticed in some other studies, on the other hand some studies demonstrate not affected-normal or lower pain thersholds but an elevated pain tolerance. [4,5]

On the other hand exercises are often prescribed in an edeavor to improve the postural control or balance of an athlete’s also in an attempt to minimize the risk of injury. Exercises of unipedal balance over an unstable and challenging surfaces are examples of good interventions that for the improvement of of athletes balance espcially after ankle sprains.[6,7]Variations between trained athletes and matched controls in ankle and knee proprioception revealed that sport participation by challenging the sensorimotor systems, can improve balance abilites and reducerisk of fall.[8.9]

Static postural control or balance can be defined as the ability to maintain a base of support with minimal movement, while dynamic postural control and balance is the ability to perform a certain task while maintaining a stable position and without any risk of fall.[10] Factors affecting balance include sensory information which is driven from the somatosensory, visual, and vestibular systems and also from the motor responses that affect the abilities of coordination, joint range of motion (ROM), and strength.[11]

By reviewing the literature of review we found previous studies suggest that excellent balance abilities among well-trained athletes are mainly the result of repetitive training experiences that influence motor responses and not greater sensitivity of the vestibular system. On the other hand, other studies debated and referred to this superior balance as a result of training experiences that enhance the ability to attend to relevant proprioceptive and visual cues. Despite the argument of experts on the mechanism, but it is agreed that balance performance is influenced by changes in both sensory and motor systems.

Different levels of sensorimotor processes are needed for each type of sport individually, in order to perform the required skills and to reduce the risk of neuromuscular system injury. Those skill requirements and environmental demands- needed to perform sports- may apply various challenges to the sensorimotor systems that in total affect the balance abilities of trained athletes.[12]

Moreover, proprioception is known to be the feedback driven from body's sensitivity to the external enviroment, that mainly leads to conscious sensation (muscle sense), total posture (postural equilibrium), and segmental posture (joint stability), which is driven by many different types of proprioceptors that are disrtributed over all body parts including the skin, muscles, tendons, ligaments, and joint capsules.[13]Research has shown that proprioception is significantly the main influencer of balance stability in lower limbs, furthermore, the reduction in the proprioceptive feedback which results from ankle injuries can apply and extravagant and inappropriate loading on a joint also it is one of the factors that leads to progressive degeneration of the joint and more extensive deficits in joint dynamics, balance, and coordination.[13]

By reviewing the previous studies, we found that the assessment of Pain perception may involve different types of stimuli such as electric current, thermal (heat or cold), mechanical (pressure, touch, vibration). While evaluation of balance includes many components, such as static postural stability, dynamic posture stability limits, and dynamic fall risk. In addition to the proprioception evaluation components that mainly include motion perception, position perception, and force sense tests [4,10,14]

Previous studies concerning the effect of sport and physical activity on all those variables have shown significant results. Meanwhile, studies discussing the relationship between pain perception, balance, and joint proprioception, and what is the long term effect of sport on those variables do not exist.

Therefore, the purpose of this study is to figure out the relationship between pain thresholds and tolerance of foot sole, static and dynamic balance and ankle joint proprioception among athletes and non-athletes, and to understand the long term effect of sport participation on this relationship. Figuring the relationship will help in developing evidence based treatment plane for many impaired physical functions in the future.

2. LITERATURE REVİEW

The pernicious effects of physical inactivity on the body, in general, are well recognized. Individuals who are classified physically inactive have an increased risk of developing heart disease that can be approximately twice more than their physically active counterparts, in addition to a variety of other known health problems as a result of the sedantarty life style and low acticity levels, such as diabetes, colon cancer, degenerative joint disease, and hypertension. On the other hand, a reduction in the risk of premature mortality, improvement of functional capacity, and ability of older individuals to maintain their independence have been shown as results of physical activity. As a result, a routine of at least 30 min of high intensity physical acticity, is given as a recommendation for adults by the Centers for Disease Control and Prevention, and the American College of Sports Medicine.[15]

The potential effect of physical activity on the human body biological processes and many variables is already clear and well discussed in the review of literature in addition to the differences between highly active and sedentary people regarding those variables were previously studied.

2.1. Pain Perception:

Since pain is one of the most important natural mechanism of the body and considered as a protection mechanism against injuries and a strong obvioussymptom for being in over use, representing an important diagnostic feature for almost all health problems, Therefore, a deeper knowledge of the effect of physical activity on pain perception and its development will affect the medical care process of pain patients in general, and the rehabilitation process for athletes in particular.

In the review of literature both pain threshold and pain tolerance were well documented and studied in order to deeply understand pain perception, and the to define the reasons standing behind pain modulation. As a definition of pain ratings, pain threshold is the lowest intensity of any stimulus that is can be recognized as a painful or a noxious stimulus. While pain tolerance is the highest amount or intensity of a specific stimulus that a person can tolerate in his normal state. Regarding the Noxious Stimulation and the tools that were used in the pain assessment they varied between (Ischemic pain, Hot and Cold water exposure, Pressure pain, or Electrical pain).

Possible Mechanisms for long term analgesia during and/or following exercise explained in the literature.

2.1.1. Possible mechanism for long term analgesia during or after exercise:

The reasons for long term analgesia following exercise are poorly under stood; however, several mechanisms exist.

The phenomenon of the exercise-induced release of endogenous opioids at either peripheral, spinal or central sites capable of pain modulation is known to be the most commonly approved hypothesis for analgesia following exercise.

Plasma β-endorphin hypotheses:

Beta-endorphins are types of proteins that are mainly produced and stored in the anterior pituitary gland from their major protein proopiomelanocortin (POMC). POMC is a large protein that is ramified into smaller types of sub-proteins such as beta-endorphin, alpha-melanocyte stimulating hormone (MSH), adrenocorticotropin (ACTH), and others.[16]

- Mechanism of action:

In the peripheral nervous system (PNS), when beta-endorphins are attached with opioid receptors (particularly of the 'mu' subtype) pain modulation is affected and leading to analgesia. This analgesic effect appears as result of their binding at both pre- and post- synaptic nerve terminals, but mainly be the presynaptic binding. When bound, an inhibition of released amount of P-type tachykinins (which is a key protein, involved in the transmission of pain) is resulted as a consecutive process of chemical interactions. As the mu-opioid receptors are found throughout peripheral nerves they also appear in the central terminals of primary afferent neurons, and the peripheral sensory nerve fibers and dorsal root ganglia.

In the central nervous system, similarly to PNS the beta-endorphins bind to mu-opioid receptors and exert their primary action at presynaptic nerve terminals. However, rather than inhibiting substance P as in PNS, they exert their analgesic effect by inhibiting the release of gamma-Aminobutyric acid (GABA), which is an inhibitory neurotransmitter, leading to an increased production of dopamine. In the CNS, mu-opioid receptors are full of descending pain control circuits including the amygdala, mesencephalic reticular formation, periaqueductal grey matter (PAG) and rostral ventral medulla.[16]

- Plasma β-endorphin levels after exercise:

E. Pierce, et.al in a study of eight females (aged between18-28) a blood sample was analysed for each subject, after the first sampling; subjects began participating in a 45-min. high intensity aerobic exercise routine constructed by an experienced physical instructor. A second blood sample was done immediately following the aerobics session. Therefore it was found that plasma P-endorphin levels were significantly elevated after exercise. [17]

Non-nociceptive afferents activation hypotheses:

During exercise, non-nociceptive afferent activity (e.g., the activity of Golgi tendon organs and muscle spindles) is increased. Since the activity of non-nociceptive afferents can modify the activity of nociceptive afferents, it is possible that pain during exercise is reduced by the increase in non-nociceptive afferent activity. [3]

Blood pressure elevation hypothesis: .
In a study of the alterations in pain perception, blood pressure and heart rate after a bout of resistance exercise for 13 adults of both genders. Pain thresholds, pain ratings, blood pressure and heart rate for both groups were measured twice, before and after a session of 45 minutes resistance exercise for the exercise group and after a resting session for the control group. Alteration of both pain thresholds and pain ratings were significantly revealed after 5 minutes of exercise in the first group, while there was no change in pain perception in the control group pain thresholds and pain ratings. Thus, it was concluded that a single bout of resistance exercise was able to influence pain sensitivity and cardiovascular responses to noxious stimulation.[4]

2.1.2 Pain ratings directly following exercise:

Typically, for this type of assessment a noxious stimulus is applied before and directly after an exercise session, in order see if analgesia will occur directly following the exercise or not. A variety of noxious stimuli types were used in previous studies to produce experimental pain such as electrical, ischemic, temperature and pressure stimulations. Researches have also studied many different mechanisms that might stand behind body's analgesic response that occurs after exercise.

Electrical Stimulation: Olausson et al. had discussed the effects of exercise and transcutaneous nerve stimulation (TNS) on pain threshold. Two assessments of pain thresholds were done for 11 participants, one before exercise and the other directly after a bout of leg and arm exercise for 20 minutes. Directly the following leg and arm exercise pain thresholds increased significantly, and then had gradually reduced to the baseline levels.[18]

Temperature Stimulation: In another study Fuller and Robinson used a heat of (44◦, 46◦, 48◦C) applied to the forearmin order to produce experimental pain for the assessment of pain perception after exercise. Twenty-two men were randomly assigned into two groups, including an exercise group where participants completed a 10km run outdoors, and a control group where participants set quietly in a laboratory for 40 minutes. A significant difference was reported between two groups.[19]

Pressure Stimulation: A third study by Koltyn et al. where he used a pressure of (3000-g force) applied to the middle digit of the right forefinger before and after a bout of exercise. A total of 16 participants were randomly assigned into two groups including exercise and no-exercise control sessions. Pain thresholds elevated immediately, and at 15 to 20 minutes following exercise in a significant elevation, while there was no change in pain thresholds following the no-exercise control group. [4]

2.1.3 Pain ratings of athletes at rest:

Meanwhile many studies were concerned about pain perception in athletes at rest, to discuss the long term effect of physical activity on pain perception by avoiding the direct effect of exercise induced analgesia which was discussed previously. Regarding this many laboratory methods for pain assessments were used in the review of literature, varied between Ischemic pain, cold presser pain, and pressure pain.

Ischemic stimulation: Ord P. and Gijsbers K., in a study including 40 subjects aged between 18-31 they have procedure experimental ischemic pain using a standard sphygmomanometer attached to the upper arm with the pressure set at 200 mm of mercury. And they found a higher pain tolerance ratings in athletes compared with non-athletes, while there was no significant difference in pain threshold between groups.[5]

Pressure pain:Erika L. Manning in a study of 24 athletes and 24 non-athletes participated in experimental pain task of pressure pain type were applied to four muscles Pectoralis, Trapezius, Biceps, Quadriceps, in order to assess pain threshold and tolerance, he found that athletes demonstrated significantly higher pressure pain threshold and tolerance than non-athletes [20]

2.2 Balance:

Balance, or postural stability, is a common term that used to describe the dynamic process by which the body is keeping a stable position and a maintained equilibrium. Body balance is in its greater level, when the body's center of mass (COM) or center of gravity (COG) is maintained over its base of support (BOS).[1]

2.2.1 Types of Balance Control:

(1) Static balance control: is the ability to maintain the body in a stable position while at rest with minimal risk of falling.

(2) Dynamic balance control: is the ability to matain the stabilized when it is stable on a moving surface or during any task rquires movement on a stable surface.

(3) Automatic postural reactions: is the ability to maintain body balance as reaction to an unexpected external actions, such as standing on a bus that suddenly accelerates22

2.2.2 Main functional goals of the balance control:

1. Keeping of a specific postural position, such as standing or sitting,

2. Facilitation of voluntary activity as movement changings between postures,

3. Activities that recover equilibrium to external disturbances, as slip or push.[23]

2.2.3 Components of Balance Control:

Balance is the complex motor control task, that involvs the revelation and integration of sensory information in order to assess bodys' position and motion in space and to find the suitable musculoskeletal responses to control a stable body position within the context of the environmental circumstances, without any risk of fall. Therfore, the nervous and musculoskeletal systems with contextual effects need to be interacted in order to maintain a state of body balance.[21]

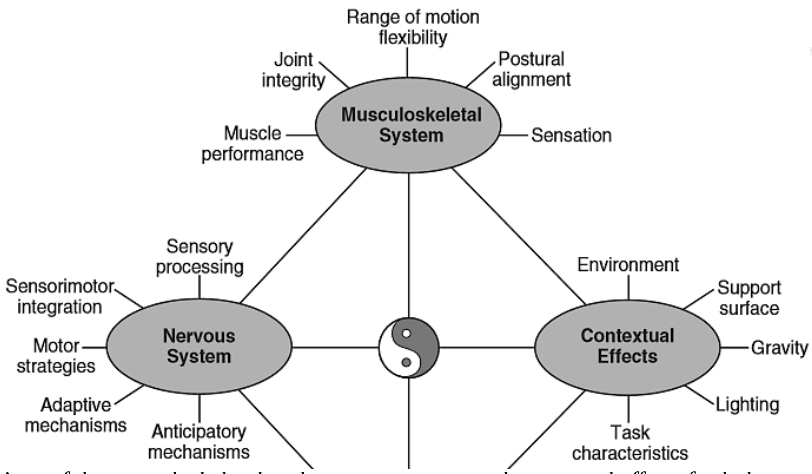


Figure 1. Interactions of the musculoskeletal and nervous systems and contextual effects for balance control.

Sensory Organization for Balance Control:

The process of integration for the incoming sensory information is being done in the cerebellum, basal ganglia, and supplementary motor area. Somatosensory inputs are more specified for the rapid responses as they have the fastest processing time and then followed by visual and vestibular inputs with slower processing times. İn case of any decrease in the information-processing rate of sensory inputs from one system due to any external environmental reason or injury, the CNS is responsible to eliminate the response to the wrong incoming input and select another appropriate sensory input from the other two systems. This response as an adaptive process is known as the sensory organization and it is used as a base of many treatment programs.[24]

2.2.4 Balance impairments:

Deficincy of balance control can be caused by musculoskeletal (i.e., poor posture, joint ROM limitations, decreased muscle performance), neuromuscular system (i.e., impaired motor coordination, pain), andneurological (e.g., stroke, traumatic brain injury, Parkinson's disease), impairments. Also postural malalignment, such as the typical thoracic, impaired ROM or muscle strength at one joint can alter posture and balance movements throughout the entire limb. In individuals with failure to generate adequate muscle forces due to abnormal tone, or impaired coordination of motor strategies may limit the person's ability to recruit muscles required for balance. Pain can alter movements, reduce a person's normal stability limits.

2.2.5 Assessment of balance control in athletes:

1. single legs standing: to check balance both static balance on firm floor; and dynamic balance on a soft or moving surface status, while standing on one leg to evaluate balance and to indicate balance problems.[25]
2. Y balance test: to evaluate dynamic balance done with stance leg maintain balance while the other leg reaches in anterior, posteromedial, and posterolateral directions. This test is helpful in the prediction of injury risk. [26,27]
3. Star excursion balance test (SEBT): to evaluate dynamic balance it requires strength, flexibility, and proprioception its used to help physical performance and prognosis of ankle instability, and determine athletes at higher risk for lower extremity injury.[28.29]

2.2.5 Athletic preformance in balance control:

It is well documented that phiysical activity assist in the improvment of proprioception, muscular strength, movement awareness, core strength and stability. These differences in joint proprioception between trained athletes and matched controls suggest that sport participation, by challenging sensorimotor systems, will enhance balance.[30.31]

Carrick, F. R. in a study comparing balance and stability between 166 elite level gymnasts and 70 non-gymnasts. a significant diffirances in balance and stability scores were found and noting that gymnasts are more stable and have a greater adaptability compared to controls.[32]

2.3 Proprioception:

The most recent refernces define proprioception as a more expert version of the sensory modality of touch thatconcests from the sensation of joint movement (kinesthesia) and joint position (joint position sense). Skin, muscles, and joints as well ligaments and tendons all are providerd with a type of receptor for proprioception that mainly functions to provide inputs to the central nervous system (CNS) about any tissue distortion. Visual and vestibular centers also share the afferent information to the CNS about body any changes in position and balance. (33)

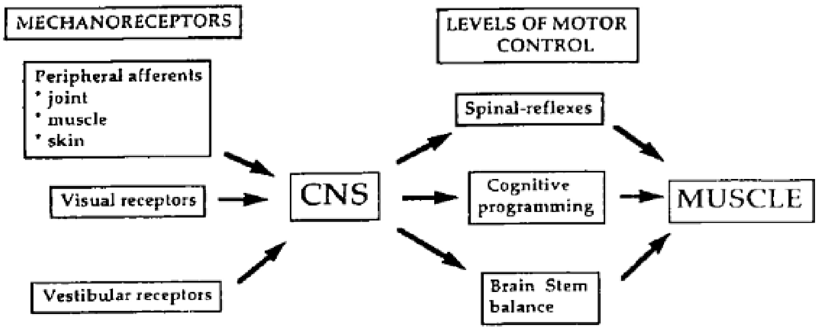


Figure 2. Neuromasular control pathways.(33)

Proprioceptors located all over the body muscles and not only functioning to provide the proprioceptive awareness about the body position and body movement, but also are functioning to protect muscles and tendons from injury by creating proprioceptive reflexes.[34] In one other study that was related to proprioception, they have discussed that proprioception's main goal is to accomplish roles in feedback and feedforward sensorimotor processes and in managing the muscle rigidity, particularly making it very important for joint stability, movement acuity, co-ordination, and balance.[35]

2.3.1 Neuroanatomical Components of Proprioceptive System:

Proprioceptive information is processed in sequence starting at the level of spinal cord, brain stem and higher cortical fields, along with subcortical cerebral nuclei and cerebellum.[36] The ascending pathways promote the transmission of the information to the medulla and thalamus, after that it forwards it to somatosensory cortex (conscious proprioception) which it is the ability to sense stimuli from within the cortexbody; or by the spinal nucleus to the cerebellum (unconscious proprioception) which is the body's reaction once a skill has been acquired.[37]

2.3.2 Directions of the proprioceptive pathways:

In the explanation of the neuroanatomical components of the proprioception, a study has given the explanations of it by dividing into the three main directions of the proprioceptive afferents and the related motor neuronal connections being involved too. Afferent direction 1, starting at the level of spinal cord, shows the proprioceptive afferent attachments on to Aα and specifically Aγ motor neurons for generating reflexes constructed in purpose of saving the joints against any possible harmful stresses. Destination 2 illustrates the pathways directed to cerebellar linkage, which are essential for maintaining the posture, balance, and motion in general. Destination 3, the cerebral cortex, is the final proprioceptive afferent direction where perception takes place and can result in proprioception.[38]

Receptors	Sensitivity	Location	Response
Muscle spindles	Subconscious muscle sense, muscle length changes	In skeletal muscles among muscle fibers in parallel with fibers	Initiate rapid contraction of stretched muscle Inhibit development of tension in antagonistic muscles
Golgi tendon organs	Subconscious muscle sense, muscle tension changes	In tendons, near muscle–tendon junction in series with muscle fibers	Inhibit development of tension in stretched muscles Initiate development of tension in antagonistic muscles
Pacinian corpuscles	Rapid changes in joint angles, pressure, vibration	Subcutaneous, submucosa, and subserous tissues around joints and external genitals, mammary glands	Provide feedback regarding location of body part in space following quick movements
Ruffini's corpuscles	Strong, sudden joint movements, touch, pressure	Skin and subcutaneous tissue of fingers, collagenous fibers of the joint capsule	Provide feedback as to exact joint angle

Figure 3. Types of Mechanoreceptors for Proprioception (39)

Mechanoreceptors are specialized nerve endings which carry the sensory information as a product of proprioception, i.e., transducers which are responsible for transforming mechanical stimulus to action potentials and carry it to the central nervous system. Mechanoreceptors that particularly contribute to proprioceptive system are named as proprioceptors, they can be found in muscle, tendon, joint and fascia, whereas, the skin receptors can be counted as contributors to proprioception too.[39]

Muscle spindles:

The most important source that contribute in the proprioception system, existing in all skeletal muscles in parallel with the extrafusal muscle fibers. They are classified as highly sensitive structures and their density depends on which part of the body they are found in, fulfilling different functional demands. Muscle spindles contain modified intrafusal fibers where they are innervated by gamma motor neurons that are different from the extrafusal muscle fibers that are supplied by alpha motor neuron.[40]

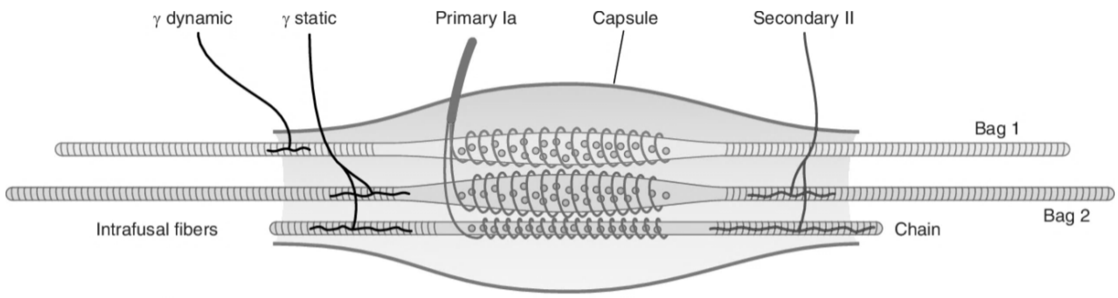


Figure 4. Diagrammatic representation of the mammalian muscle spindle (41)

Golgi tendon organs:

For the procession of the proprioceptive information, Golgi tendon organs (GTO) are considered as another important contributors, which are located in muscle tendons. They help in the protection of the muscle from being overloaded, when the muscle tension increases. Ib sensory axions carry all the tension information that has to be with this overload on the muscles and which GTOs are innervated from.[41]

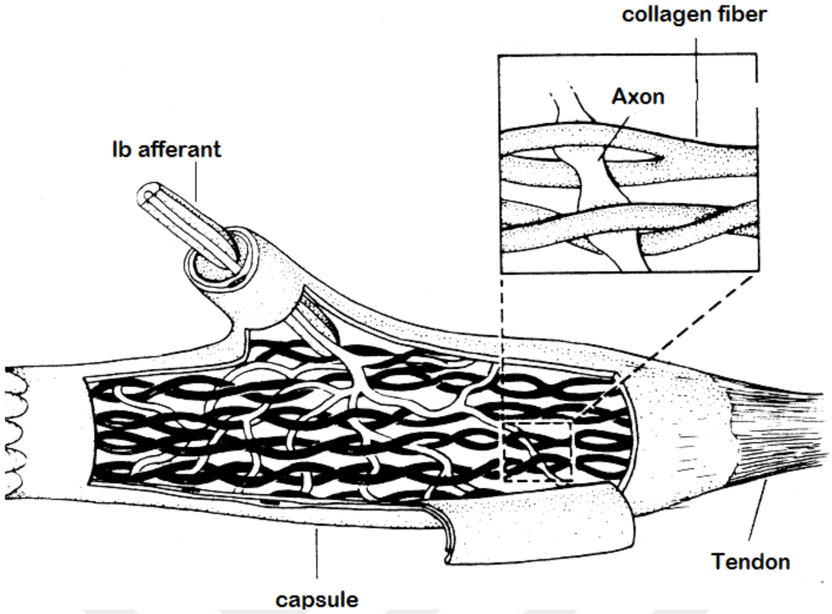


Figure 5. Diagrammatic representation of the Golgi tendon organs (42)

2.3.3 Proprioception deficits:

It was found in the review of literture that many conditions can lead to a notable decline of proprioception. Neurological and orthopedical problems such as strok[43.44], Parkinson's disease [45], focal dystonia [46], peripheral neuropathies or soft tissue injuries as ligaments, joint capsules and mucles [47]; are correlated with damages in proprioception and motion destruction.

Also ot has been found that impaired proprioception have correlations with other problems such as pain, trauma, effusion and fatigue. Also regional musculoskeletal pain in cervical spine [48], lumber spine [49], upper extremities [50] and lower extremities. [51]

These imparmints in the proprioception have adverse effects on motor control and muscular arrangements, leading to a variety of known clinical complaints such as balance control impairment and clumsiness in musculoskeletal disorders. Leading to impaired motor output from the central nervous system, which obstructs muscular protection of joint tissues may be patho-physiologically correlated with high risk of injury and recurrence and persistence of pain disorders, including the onset and progression of secondary osteoarthritis. [52]

2.3.4 Propriocaption evalution:

Testing of proprioception can be done in two ways, rather passive or active or expressing in other words, biasing the mechanoreceptors of the joints or stimulating muscle-tendon mechanoreceptors. Assessment of individual's proprioception includes two techniques joint position sense, motion or force sense. [53]

Joint position sense

By testing the capability to sense the static location of a joint or an extremity. It generally focuses on how one person can be accurate in producing or matching a given joint angle in the elimination of sight, and thus these tests can be done in two ways. First, in ipsilateral remembered matching tasks, the examiner displaces the joint of the patient to a target angle, holds it for several seconds and returns back to starting position. After this demonstration, the patient is asked to replicate the same motion based on the proprioceptive memory. Whereas, the second method is named as contralateral concurrent matching, where the examiner does the same displacement of the patient's joint to a target angle and holds the movement at the same place without bringing it to starting point. In this part, is asked from the patient to produce the same matching motion with the contralateral extremity. [54]

Motion sense:

Evaluating the ability to recognize joint movement using three methods which include threshold to detection of passive motion TTDPM [55], movement discrimination tests [56], or the acuity of a tracking task [57].

In the motion sense assessment many of the variables are mostly determined in JPS, TTDPM and force sense tests as mentioned before. These variables include constant error (CE), variable error (VE) and absolute error (AE). In order to get accurate mean values from the joint that is being tested, earlier researchers suggested to perform the assessment using three to five test trials. [58]

2.3.5 Proprioception and exercise:

In a study of 40 subjects (20 gymnastics and 20 normal life style subjects), sense of position of a joint was assessed in active and passive ways. Results revealed statistically significant differences between two groups. Suggesting that gymnastic training has a positive influence on ankle joint sense of position and balance, in addition to improvement of muscle tone. [30]

Considering the huge role of proprioception in the maintenance of postural stability, movement control, and injury prevention, then, understanding the effects of exercise on proprioception function would be advantageous and will play a critical role at the process of injury treatment. Foot and ankle articulation as a complex functions as the first structure in postural stability, which makes it a highly risked structure with injuries in all sports. Therefore, considering foot and ankle injury prevention, regardless prophylactic devices, proprioception training is needed as a part of the therapeutic exercising program to enable athletes regaining their perjury levels of activity after ligament or muscle injuries. Although it is still debatable whether proprioception if it can be improved by exercise training or not.

3.MATERIALS & METHODS

3.1 Study Design:

This research is a correlational non-experimental study, which was conducted in the physiotherapy laboratory of Yeditepe University.

3.1.1 Sample size:

The sample size was calculated by using G*Power 3.1.to be 42 participents , 22 in each group.

3.2 Participants:

Participants are 42 volunteers. The athletes were recruited from the sports teams of Yeditepe University football,basketball and dancing clubs, while the non-athletes group participants are student from Yeditepe University collages, All participants voluntarily accepted to participate in this study, being asked directly to volunteer after the nature of the procedure was explained to them in details. Ethical approval for the study was obtained from Yeditepe University (Appendix A). A sample of voluntary consent form is given in (AppendixB and C) in Turkish and English.

All participants signed an informed consent detailing the study objectives, general details of the experimental protocol and reimbursement. In order to remove any possibility of demand characteristics, the consent did not contain any language related to learning or threatening stimuli. In addition to a consent translated into the Turkish language for Turkish students who are not fluent in English.

3.2.1 Inclusion criteria:

1. Healthy males and females
2. Older than 18.
3. No functional limitations
4. For participants of athletic group: They should be participating regularly in any type of sport 3 days a week for the last 6 months at least.

3.2.2 Exclusion criteria:

1. Cardiac, orthopaedic or neuromuscular patients.
2. Athletes who suffered from previous field injury that not fully recovered yet.
3. History of pain or discomfort in lower back and lower extremities
4. History of systemic or underlying diseases (such as diabetes, hypertension, etc.)
5. Inability to follow instructions.
6. Pregnant females.

We were sure that all participants did not perform any strong exercise or effort for three hours before the assessment to avoid the effect of (acute exercise induced analgesia).

• Athletes group number 21 (8 females 14 males)

• Non-Athletes number 21 (10 females 12 males).

3.3 Assessment methods:

All prticipents from both groups went through the same evaluation procedure in the same order. Each participant was given his own time separately. An example of the evaluation form is given in (Appendix D). For subjects from the atheltic group were asked about the type of exercise they are doing at ,how many years days and hours of prcatice.

3.3.1. Body Mass Index

Body mass index was calculated after taking the measurements of height and weight. The formula is BMI = kg/m2 where kg is a person's weight in kilograms and m2 is their height in metres squared.

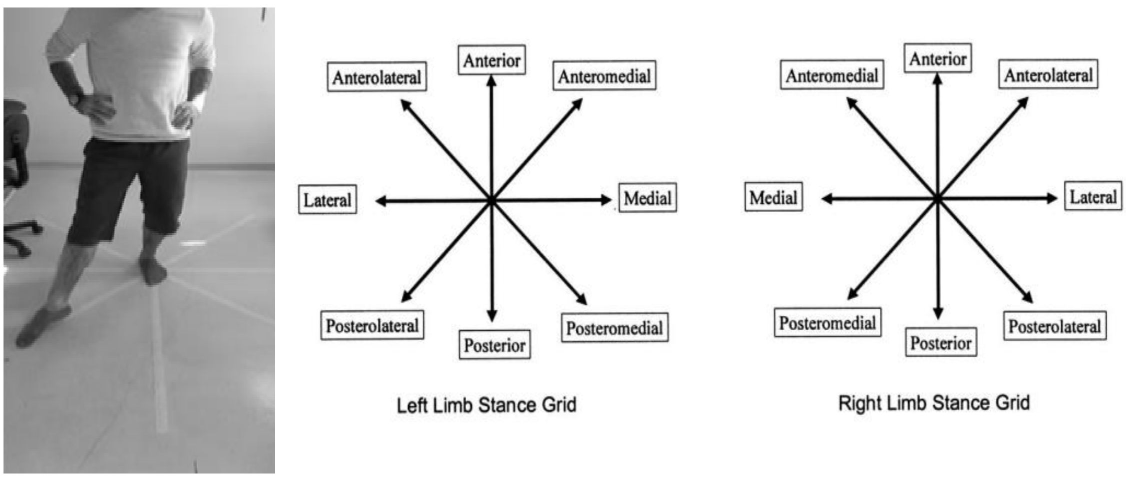
3.3.2 Pain perception assesment:

This part was done using an algometer (push-pull baseline dolorimeter 66LB/30KG) (Figure 6). The subject was in a long sitting position, and the examined foot is holded by the examiner to apply a pressure using the dolorimeter over the most three loaded points of foot sole which are under the first and fifth metatarsals in addition to the mid point under heel, (Cavanagh, 1987). The subjects is asked to give a verbal sign as (PAIN) when the pressure feeling turns painful as (pain threshold) and another second sign as (STOP) when he cannot tolerate more pressure as (pain tolerance). Pain threshold and tolerance readings were noted of the three points for each foot individually. [21]

Figure6. Pain Perception. A) The examiner applies pressure over the defined three points. B) Type of Algometer used to produce experimental pressure pain.

3.3.3 Star excursion balance test (SEBT):

It consists of series of single-limb squats on the non-stance limb in order to reach the maximal point along 1 of 8 designated lines on the ground. The lines are arranged in a grid which star like shaped and extends from a center point and are 45◦ from one another (Figure 7). The task of reaching each direction providers a different challenge and requires the combinations of sagittal, frontal, and transverse movements. [59]



(Figure 7) dynamic balance A) Participant preforming SEBT. B) SEBT gird.

The SEBT was performed with the subject standing barefoot at the center of a grid laid on the floor (Figure 7). Subjects maintained a single-leg stance while reaching with the contralateral leg to touch as far as possible along the chosen line. Subjects touched the furthest point possible on the line with the most distal part of theirreach foot. Subjects then returned to a bilateral stance while maintaining their equilibrium.

The examiner marked the point touched along the line so a reading can benoted and total of 3 trials was performed for each leg on each direction. Reach distances were then normalized to subjects' leg length, which was measured from the anterior superior iliac spine to the distal tip of the medial malleolus. (Figure 7).

3.3.4 The single leg standing test (SLS):

The test is used to assess participant's ability to keep his balance while standing on one leg. Participants were asked to stand without any assistance on one leg for one minute with the eyes opened and time is counted in seconds from the time when the foot is flexed off the floor to the time when it touches the ground. Prior to raising the limb, the subject was instructed to place his arms over the hips. The investigator used a stopwatch to count time the subject was able to stand on one limb. Time counting started when the subject raised his foot off the floor. And time ended when the subject either: (1) unplace his arms from hips, (2) used the raised foot (moved it toward or away from the standing limb or touched the floor), or (3) a maximum of 1 minute had elapsed.

Figure 8. Single leg Standing Test.

3.3.5 Proprioception assessment:

Assessment was carried in two stages.

3.3.5.1 Joint Position Sense: (Angle reproduction test)

Participants performed the assessment in an upright sitting position, in a chair, joints alignment was in the 90-degree position for hip and knee.

- **Ankle dorsiflexion**: target angle was15° of dorsiflexion. Examiner was demonstrating the target angle using a goniometer. Participants were asked to look at the angle achieved, and then the participant was asked to demonstrate the same angle with the eyes closed. Assessment was carried for both legs for three trials and mean value was taken and noted in the data collection form.
- **Ankle planter flexion**: target angle was10° of ankle planter flexion. Examiner was demonstrating the target angle using a goniometer. Participants were asked to look at the angle achieved, and then the participant was asked to demonstrate the same angle with the eyes closed. Assessment was carried for both legs for three trials and mean value was taken and noted in the data collection form. [58]

Figure 9. Angle Reproduction Test

3.3.5.2 Motion Sense:

Participants performed the assessment in an upright sitting position, on a chair. Joints that were assessed are the 1st Metatarsophalangeal and 5th Metatarsophalangeal (MTPJ) joints.

Examiner asked participants to close their eyes while the examiner performed movement of up and down directions (planter flexion and dorsiflexion) in the1st MTPJ 5th MTPJ from distal to proximal and taking feedback from the participants. A total of 3 movements in different directions were performed for each joint. All the information was noted by the examiner in the data collection form. [58]

Figure 10 Joint Position Sense.

3.4 Equipment:

Tools that were used in the procedure are: stop watch, weight scale, measuring tape, a push-pull baseline dolorimeter (66LB/30KG), star excursion balance test gird, firm chair without arms, goniometer.

4.RESULTS

4.1 Sociodemographic Results

Table 1: Athlete Socio-Demographic Variables

	Mean±SD Min-Max
Female	7 33.6%
Male	14 67.7%
Age	23.28±2.81 20-28 Years
Years of Practice (Year)	3.54±1.89 1-7 Years
Days of Practice (Days)	3.9±1.13 3-6 Days
Hours of Practice (Hour)	1.73±.33 1- 2.5 Hours
Weight	74.38±16.80 51-120 Kg
Height	176.52±8.09 158-191 Cm
BMI	22.71±3.61 15.6-29.3

M= Mean, SD = standard deviation, Min= minimum, max= maxim.

Table1 shows a descriptive data of the Sociodemographic of athletes

Table 2: Non-Athlete Socio-Demographic Variables:

	Mean±SD Min-Max
Gender Female	9 Females 42.9%
Gender Male	12 Males 57.1%
Age(years)	22.04 ±3.13 20-30 Years
Weight	71.95 ±16.42 48-106 Kg
Height	172.42 ±8.28 159-186 cm
BMI	24.19 ±4.15 17.8-31.3

M= Mean, SD = standard deviation, Min= minimum, max= maxim.

Table 2 shows the descriptive data of the Sociodemographic of athletes group and non-athletes group.

Table 3: T sample test for Age, Weight, High, and BMI:

	Athletes Mean±SD	Non-athletes Mean±SD	p
Age	23.28 Years ±2.81	22.04 Years ±3.13	0.184
Weight	74.38 Kg ±16.80	71.95 Kg ±16.42	0.638
High	176.52 cm ±8.09	172.42cm ±8.28	0.112
Body mass index (BMI)	22.71 ±3.61	24.19 ±4.15	0.225

*p<0.05, M= Mean, SD = standard deviation

Also non-athletic participants showed a slightly higher mean of BMI values of (24.1) when compared to (22.7), without any significant differences, knowing that both results considered to be normal BMI ≤ 25.

2.4 Body Mass Index Results:

Table 4: BMI score for athletes and non-athletes:

Subject	Male Means(SD)	Female Means(SD)	P
Athletes	24.34(2.50)	19.45(3.37)	0.00*
Non-Athletes	25.17 (3.92)	22.89 (4.32)	0.222

*p<0.05, BMI: body index, M= Mean, SD = standard deviation

Table 4 There was a significant difference of BMI between males and females in the athletic group (*p<0.05). But there was no significant difference between males and females within the non-athletes group (*p>0.05). although males showed higher results than females.

2.3 Pain Perception:

Table 5: pain threshold and pain tolerance ratings results for athletes and non-athletes:

	Athlete Mean (SD)	Non-athleteMean (SD)	P
Pain Th. Right	12.24 Kg(2.77)	9.41 Kg (2.13)	0.00*
Pain T.Right	16.31 Kg (3.04)	12.16 Kg (2.88)	0.00*
Pain Th. Left	13.31 Kg (3.50)	9.76 Kg (2.32)	0.00*
Paint T. Left	16.61 Kg (3.46)	12.82 Kg (3.26)	0.00*

***p<0.05**Pain Th. = Pain Threshold, Pain T. =Pain Tolerance, M= Mean, SD = standard deviation.

Significant differences were found between groups for pain thresholds and pain ratings on both right and left sides (p<0.05). As athletes showed higher results for pain thresholds and pain tolerance ratings on both left and right sides when compared to non-athletes.

Table 6: Pain threshold and pain tolerance ratings results for male and female:

	Male Mean (SD)	Female Mean (SD)	P
Pain Th. Right	11.87 Kg (2.72)	9.13 Kg (2.16)	0.00*
Pain T.Right	15.68 Kg (3.42)	11.90 Kg (2.55)	0.00*
Pain Th. Left	12.98 Kg (3.41)	9.19 Kg (1.85)	0.00*
Paint T. Left	16.60 Kg (3.40)	11.65 Kg (2.18)	0.00*

***p<0.05**Pain Th. = Pain Threshold, Pain T. =Pain Tolerance, M= Mean, SD = standard deviation.

Significant differences were found between genders in all pain thresholds and pain ratings on both right and left sides (p<0.05). As males showed always higher pain ratings when compared to females.

Table7. Pearson Correlation: BMI and Pain Perception for Athletes:

	BMI	Pain th Rt.	Pain T Rt.	Pain th Lt.	Pain T Lt.
BMI	*	.677*	.624**	.573**	.598**
Pain th Right		*	.901**	.773**	.782**
Pain T Right			*	.881**	.880**
Pain th Left				*	.909**
Pain T Left					*

**p<0,01, *p<0,05 Pain Th. = Pain Threshold, Pain T. =Pain Tolerance.

Table7 shows that there is meaningful relationship between BMI and Pain Th Lt. for athletes (r= .677; p< .05).

And a stronger meaningful relationship between MBI and Pain T Rt. (r=.624), Pain th Lt. (r=.573) and Pain T Lt. (r=.598) (p<0,01) for athletes.

Table 8. Pearson Correlation: BMI and Pain Perception for Non-Athletes

	BMI	Pain th Rt.	Pain T Rt.	Pain th Lt.	Pain T Lt.
BMI	*	.415	.369	.454*	.517
Pain th Right		*	.916*	.938*	.810**
Pain T Right			*	.923**	.802**
Pain th Left				*	.787**
Pain T Left					*

**p<0,01, *p<0,05 Pain Th. = Pain Threshold, Pain T. =Pain Tolerance.

Table 8 shows that there is meaningful relationship only between BMI and Pain th Lt. for non-athletes (r= .454; p< .05).

A leaner relationship was found between pain ratings and BMI.

4.4 Joint Proprioception Results:

1.4.4 Sense of motion:

TABLE 9: Sense of motion of the athletic group:

	N	**%**
right 1st MTP DF		
Yes	18	85.7%
No	3	14.3%
right 1st MTP PF		
Yes	20	95.2%
No	1	4.8%
right 5th MTP DF		
Yes	21	100%
No	0	0%
right 5th MTP PF		
Yes	21	100%
No	0	0%
left 1st MTP DF		
Yes	19	90.5%
No	2	9.5%
left 1st MTP PF		
Yes	19	90.5%
No	2	9.5%
left 5th MTP DF		
Yes	21	100%
No	0	0%
left 5th MTP PF		
Yes	21	100%
No	0	0%

1st MTP= first metatarsophalangeal joint, 5th MTP= fifth metatarsophalangeal joint, PF= planter flexion, and DF= dorsiflexion.

(Table 9) showing the results of planter flexion and dorsiflexion Sense of motion for 1st and 5th metatarophalangeal joints. Results showed diffirences among 1st Ms joint, giving the right side with (85.7%) of dordiflexion and (95.2%) of planter flexion, and (90.5%) of dordiflexion and (90.5%) of planter flexion. Meanwhile there was no diffirence among 5th Ms, as all participantes were able to diffrentiate the direction of moition.

TABLE 10: Sense of motion of the non-athletic group:

	N	%
Right 1st Ms DF		
Yes	17	81%
No	4	19%
Right 1st Ms PF		
Yes	14	66.7%
No	7	33.7%
Right 5th MTP DF		
Yes	21	100%
No	0	0%
Right 5th MTP PF		
Yes	21	100%
No	0	0%
Left 1st MTP DF		
Yes	14	66.7%
No	7	33.3%
Left 1st MTP PF		
Yes	13	61.8%
No	8	38.1%
Left 5th MTP DF		
Yes	21	100%
No	0	0%
Left 5th MTP PF		
Yes	21	100%
No	0	0%

1st MTP= first metatarsophalangeal joint, 5th MTP= fifth metatarsophalangeal joint, PF= planter flexion, and DF= dorsiflexion.

(Table 10) showing the results of planter flexion and dorsiflexion Sense of motion for 1st and 5th metatarophalangeal joints. Table showed higher positive results on the right side of 1st MPT joint, with (81%) of dordiflexion and (66.7%) of planter flexion, and (66.7%) of dordiflexion and (61.8%) of planter flexion. Meanwhile there was no diffirence among 5th MTP, as all participantes were able to diffrentiate the direction of moition.

Table 11:Comparing sense of motion results for athletes and non-athletes:

	Yes % of athletes	Yes % of non-athletes
Right 1st MTP DF	85.7%	81%
Right 1st MTP PF	95.2%	66.7%
Right 5th MTP DF	100%	100%
Right 5th MTP PF	100%	100%
Left 1st MTP DF	90.5%	66.7%
Left 1st MTP PF	90.5%	61.8%
Left 5th MTP DF	100%	100%
Left 5th MTP PF	100%	100%

1st MTP= first metatarsophalangeal joint, 5th MTP= fifth metatarsophalangeal joint, PF= planter flexion, and DF= dorsiflexion.

(Table 11) shows the differences between athletic and non-athletic groups results of joint motion sense, there was differences among 1st MTP Joint planter flexion and dorsiflexion on both sides, meanwhile there was no diffirences among the results of 5th MTP Joint as all participants were able to diffrantiate the direction of motion.

2.3.4 Angle reproduction test:

Table 12: Results of angle reproduction test on ankle for athletes and non-athletes.

	Athlete M (SD)	**Non-Athlete** M (SD)	**p**
Right Ankle DF Angle Error	0.71◦ (0.61)	1.16◦ (0.81)	0.04*
Right Ankle PF Angle Error	0.8◦5(0.64)	1.33◦ (0.62)	0.01*
Left Ankle DF Angle Error	0.73◦ (0.65)	1.08◦ (0.59)	0.04*
Left Ankle PF Angle Error	0.73◦ (0.71)	1.21◦ (0.72)	0.03*

***p<0.05**, PA= perceived angle, DF= dorsiflexion, PF= planter flexion, M= Mean, SD = standard deviation.

In the (Table12) Independent Sample t-test was used to find the differences between athletes and non-athletes in angle reproduction test results.

There were significant differences between athletes and non-athletes in the angle reproduction test results among ankle joint in planter flexion and dorsiflexion for both right and left sides ($p<0.05$).

Table 13: Results of angle reproduction test on ankle joint for males and females.

	Male M (SD)	**Female** M (SD)	**p**
Right Ankle DF Angle Error	0.94◦ (0.34)	1.25◦ (0.50)	0.03*
Right Ankle PF Angle Error	0.94◦ (0.55)	1.37◦ (0.71)	0.04*
Left Ankle DF Angle Error	0.86◦ (0.58)	1.23◦ (0.36)	0.01*
Left Ankle PF Angle Error	0.91◦ (0.54)	1.26◦ (0.41)	0.02*

***p<0.05**, AAE= actual angle error, DF= dorsiflexion, PF= planter flexion, M= Mean, SD = standard deviation.

In the (Table13) Independent Sample t-test was used to find the differences between male and female in angle reproduction test results. There were significant differences between males and females in the angle reproduction test results among ankle joint in planter flexion and dorsiflexion for both right and left sides ($p<0.05$).

Table 14: Pearson Correlation: BMI and Proprioception for Athletes:

	BMI	Ankle DF Rt.	Ankle PF Rt.	Ankle DF Lt.	Ankle PF Lt.
BMI	*	.181	.048	.159	.116
Ankle DF Rt.		*	-.129	.097	-.215
Ankle PF Rt.			*	.152	.008
Ankle DF Lt.				*	.585**
Ankle PF Lt.					*

**p<0,01 , *p<0,05

DF Rt. = dorsiflexion right side, **PF Rt.** = planter flexion on the right side, **DF Lt. =** dorsiflexion right side, **PF Lt. =** planter flexion on the left side.

Table14 shows that there is no any meaningful relationship between body mass index and ankle proprioception among athletes.

Table 15: Pearson Correlation: BMI and Proprioception for Non-Athletes:

	BMI	Ankle DF Rt.	Ankle PF Rt.	Ankle DF Lt.	Ankle PF Lt.
BMI	*	.020	-.102	-.055	-.125
Ankle DF Rt.		*	.254	.224	-.392
Ankle PF Rt.			*	-.038	.072
Ankle DF Lt.				*	.001
Ankle PF Lt.					*

**p<0,01 , *p<0,05

BMI = Body mass index, **DF Rt.** = dorsiflexion right side, **PF Rt.** = planter flexion on the right side, **DF Lt. =** dorsiflexion right side, **PF Lt. =** planter flexion on the left side.

Table15 shows that there is no any meaningful relationship between body mass index and ankle proprioception among non-athletes.

5.4 Balance scores:

Table 16: Results of SEBT for athletes and non-athletes.

Subject	Athletes	Non-athletes	P
	Mean (SD)	Mean (SD)	
AntR	88.78cm (9.76)	79.43 cm (9.05)	0.00*
AntLatR	88.41 cm (11.33)	80.44 cm (7.73)	0.01*
AntMedR	87.06 cm (8.28)	76.46 cm (7.87)	0.00*
MedR	98.20 cm (3.08)	83.10 cm (8.75)	0.00*
LatR	103.21 cm (3.82)	85.84 cm (6.16)	0.00*
PostR	96.55 cm (6.95)	82.08 cm (9.38)	0.00*
PostLatR	87.06 cm (8.28)	76.46 cm (7.87)	0.00*
PostMedR	88.33 cm (9.87)	81.84 cm (5.64)	0.00*
AntL	87.88 cm (10.79)	80.97 cm (6.19)	0.00*
AntLatL	88.76 cm (7.89)	78.61 cm (9.48)	0.00*
AntMedL	71.57 cm (16.70)	75.90 cm (8.80)	0.30
MedL	88.76 cm (7.89)	78.61 cm (9.48)	0.00*
LatL	102.68 cm (7.00)	83.68 cm (6.71)	0.00*
PostL	101.15 (6.03)	83.84 cm (5.12)	0.00*
PostLatL	90.05 cm (15.42)	80.84 cm (7.46)	0.00*
PostMedL	88.33 cm (9.87)	81.84 cm (5.64)	0.00*

*p<0.05, AntR=anterrior right. AntlatR= anterior lateral right. AntMedR= anerior medial right, MedR=Medal right, LatR=Latral right, postR=posterior right, PostLatR=Posterolateral right, PostMedR= posteromedial right. , AntL=anterrior left. Antll= anterior lateral left. AntMedl= anerior medial left, MedL=Medal left, LatL=Latral left, PostL=postorior left, Postlatl=Posteriolateral left, postMedL= posteromadial left. M= Mean, SD = standard deviation.

(Table16)There was a significant difference in (SEBT) scores between athletes and non-athletes (p<0.05), as Athletes recorded significantly higher scores than non-athletes in all eight directions for both right and left sides.

Table 17:Results of SEBT for male and female:

*p<0.05 , AntR=anterrior right. AntlatR= anterior lateral right. AntMedR= anterior medial right, MedR=Medal right,

Subject	Female	Male	P
	Mean (SD)	Mean (SD)	
AntL	83.51 cm (11.14)	85.90 cm (5.39)	0.78
AntLatL	78.88 cm (12.62)	84.06 cm (12.21)	0.14
AntMedL	72.15 cm (14.72)	74.71 cm (12.61)	0.549
MedL	81.92 cm (9.68)	84.77 cm (10.27)	0.36
LatL	91.30 cm (11.77)	94.33 cm (11.83)	0.41
PostL	89.18 cm (9.48)	94.54 cm (10.51)	0.09
PostLatL	83.78 cm (14.90)	86.47 cm (11.58)	0.51
PostMedL	84.08 cm (7.68)	85.71 cm (9.19)	0.53
AntR	83.55 cm (11.33)	85.01 cm (9.11)	0.64
AntLatR	81.40 cm (9.75)	86.30 cm (10.52)	0.12
AntMedR	77.51 cm (15.62)	77.98 cm (14.47)	0.9
MedR	89.27 cm (10.61)	91.50 cm (9.75)	0.48
LatR	93.18 cm (10.51)	95.35 cm (10.03)	0.49
PostR	89.17 cm (9.48)	89.40 cm (11.96)	0.95
PostLatR	79.75 cm (9.98)	83.00 cm (9.39)	0.28
PostMedR	83.68 cm (6.60)	81.59 cm (10.44)	0.44

LatR=Latral right, postR=posterior right, PostlatR=Posterolateral right, postMedR= posteromedial right. , Antl=anterrior left. Antlatl= anterior lateral left. AntMedl= anterior medial left, Medl=Medal left, Latl=Latral left, postl=posterior left,Postlatl=Posterolateral left, postMedL= posteromedial left. M= Mean, SD = standard deviation

There was no significant difference between male and female in the scores of (SEBT) (p>0.05), mentioning that male always showed higher scores compared with females except in the posteromedial direction just as all the previous studies in the review of literature but the differences were not significant enough.

Table 18: Pearson Correlation: BMI and Dynamic Balance (SEBT) for Athletes:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	*	.173	.542*	.247	.020	0.127	-.001	.148	.216	.094	.053	.104	.138	-.082	.142	.317	.188
2		*	-.011	-.081	.098	.036	-.300	-.173	.387	.475*	.456*	.524*	.446*	-.037	.154	.074	-0.32
3			*	.786*	.249	.225	-.190	.217	-.243	-.073	-.342	.498*	-.302	-.114	.169	.711	.716*
4				*	.115	-.408	-.307	.545*	.443*	-.253	-.413	.665*	.498*	-.235	-.185	.857*	.760*
5					*	.272	.117	-.138	-.375	-.282	-.104	.063	.056	.487*	.470*	.333	.307
6						*	.226	.438*	.018	-.317	-.255	.139	.352	.707*	.675*	-.216	-.214
7							*	.326	-.150	-.139	.-041	.099	.221	.388	.133	-.357	.058
8								*	.356	.066	.212	.262	.251	.063	.298	.675*	.620*
9									*	.622**	.684**	.444*	.506*	-.325	-.071	-.497*	-.494*
10										*	.680**	.430	.184	-.502	-.131	-.260	-.246
11											*	.588**	.397	-.360	-.247	-.348	-.436*
12												*	.597**	-.041	.058	-.472*	-.534
13													*	.208	.340	-.369	-.210
14														*	.548*	-.010	.141
15															*	-.061	.078
16																*	.829**
17																	*

**p<0,01 , *p<0,05, 1=BMI 2=AntR 3=AntLatR 4=AntMedR 5=MedR 6=LatR 7=PostR 8=PostLatR 9=PostMedR 10=AntL 11=AntLatL 12= AntMedL 13=MedL 14=LatL 15=PostL 16=PostLatL 17=PostMedL

Table 18 shows that there is no meaningful relationship between BMI and dynamic balance with Star Excursion Balance Test (SEBT) among athletes, as there was no correlation between them except on the Anterolateral direction (r=.542, p<0,05).

Table 19: Pearson Correlation: BMI and Dynamic Balance (SEBT) for Non-Athletes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	*	-.384	-.124	.105	-.411	-0.198	.101	.220	-.186	-.032	-.118	-.017	.155	.112	-.234	-.008	.110
2		*	.278	.024	.199	.487*	-.010	.365	.569*	.216	.623*	.387	.245	.011	.407	-.142	.297
3			*	.508*	.119	.051	.163	.155	.136	.117	.042	-.058	.208	.117	.198	.239	.502*
4				*	.367	.269	.391	.154	.334	.402	.016	-.020	.268	.357	.137	.575**	.669**
5					*	.564**	.480*	.220	.546*	.483*	.479*	.433	.343	.637**	.509*	.120	.192
6						*	.342	.339	.532*	.400	.507*	.521*	.405	.428	.085	-.374	.045
7							*	.426	.438*	.607*	.443*	.148	.514*	.623**	-.289	.046	.275
8								*	.662	.409	.480*	.310	.230	.532*	.220	-.194	.153
9									*	.569*	.707*	.555*	.330	.601**	.477*	.029	.292
10										*	.459*	.157	.412	.571**	.352	.003	.376
11											*	.637*	.547*	.387	.372	-.197	.272
12												*	.524*	.326	.386	-.087	.140
13													*	.334	.241	-.047	.385
14														*	.439*	-.077	.148
15															*	.278	.410
16																*	.606**
17																	*

**p<0,01 , *p<0,05, 1=BMI 2=AntR 3=AntLatR 4=AntMedR 5=MedR 6=LatR 7=PostR 8=PostLatR 9=PostMedR 10=AntL 11=AntLatL 12= AntMedL 13=MedL 14=LatL 15=PostL 16=PostLatL 17=PostMedL

Also among non-athletes no any meaningful relationship was found between BMI and dynamic balance when tested with Star Excursion Balance Test (SEBT).

2.5.4 Single leg standing test: (static balance)

Table 20: Results of SLST for athletes and non-athletes.

	Athlete	Non-athlete	p
	M (SD)	M (SD)	
SLST Right	54.45sec (9.45)	51.15 sec (15.03)	0.39
SLST Left	53.27 sec (12.60)	46.78 sec (13.39)	0.11

***p<0.05** M= Mean, SD = standard deviation

Athletes scored higher mean of time on both legs (right=54.45 sec) and (left=53.27 sec) when compared to non-athlete group. Although those differences were not significant when compared to previous studies that showed better results in static balance among athletes (p>0.05).

Table 21: Results of SLST for male and female:

	Male	Female	p-value
	M (SD)	M (SD)	
SLST Right	54.88 sec (11.45)	51.52 sec (13.17)	0.40
SLST Left	50.36 sec (14.56)	49.82 sec (12.69)	0.90

***p<0.05** M= Mean, SD = standard deviation

There were no significant differences between male and female in the scores of static balance (p>0.05), however males recorded a noticeable longer time in single leg standing while controlling balance on both left and right sides.

Table 22: Pearson Correlation: BMI and Static Balance for Athletes:

	BMI	SLST Rt.	SLST Lt.
BMI	*	.004	.184
SLST Rt.		*	.779**
SLST Lt.			*

**p<0,01, *p<0,05

BMI= Body mass index, SLST Rt. =Single leg standing right, SLST Lt. = Single leg standing left.

There is no meaningful relationship between BMI and static balance when tested with single leg standing test among athletes.

Table 23: Pearson Correlation: BMI and Static Balance for Non-Athletes.

	BMI	SLST Rt.	SLST Lt.
BMI	*	-.018	.147
SLST Rt.		*	.400
SLST Lt.			*

**p<0,01, *p<0,05

BMI= Body mass index, SLST Rt. =Single leg standing right, SLST Lt. = Single leg standing left.

Also among athletes no meaningful relationship was found between BMI and static balance when tested with single leg standing test.

5.4 Correlation between pain perception, joint proprioception and balance scores:

	Pain Th.	Pain T.	Ankle DF	Ankle PF	Ant	Ant. Lat.	Ant. Med.	Med.	Lat.	Post.	Post. Lat.	Post. Med.	SLST
Pain Th.	*	.930**	-.163	-.041	.061	0.249	.180	.195	.354*	.231	.300	.057	-.157
Pain T.		*	.124	-.100	,018	.175	.066	.235	.434**	.341*	.394**	.110	-.158
Ankle DF			*	.066	.131	.047	.117	.225	.141	.084	-.005	-.038	.086
Ankle PF				*	.177	.141	.084	.060	.068	-.139	-.124	-.080	.168
Ant.					*	.346*	.109	.430**	.292	.090	.170	.353*	-.127
Ant. Lat.						*	.711**	.367*	.050	.028	-.070	-.086	.017
Ant. Med.							*	.277	-.009	.012	.241	-.170	.047
Med.								*	.690**	.592**	.351*	.363*	-.060
Lat.									*	.686**	.626**	.496**	-.105
Post.										*	.638**	.475**	-.023
Post. Lat.											*	.649**	-.064
Post. Med.												*	-.129
SLST													*

**p<0,01 , *p<0,05, Pain Th. =pain threshold, Pain T.= pain tolerance, Ankle DF =dorsiflexion, Ankle PF= planter flexion, Ant=anterior, Ant. Lat. = anterolateral, Ant. Med. = Anteromedial, Med = medial, Lat. = lateral, Post = posterior, Post. Lat. =Posterolateral, Post/ Med =Posterolateral, SLST = single leg standing test, D=dominant side.

In (Table 13) pain perception showed a positive correlation only with lateral direction of SEBT (r=**.345**, p<0, 05). Meanwhile there was no significant correlation with the rest of the directions or other variables of proprioception and static balance. Pain tolerance ratings showed a positive correlation with lateral direction (r=**.434,** p<0,01), posterior direction (r=**.341,** p<0,05), and posterior medial direction (r=**.394,** p<0,01). Meanwhile there was not any other correlation with any of the other variables. Ankle joint proprioception presented by angle reproduction test in planter flexion and dorsiflexion did not show any correlation with any of the other variables.

Anterior direction of SEBT showed a positive correlation with each of anterolateral direction (**r=.346**,p<0.05), medial direction (**r=.430**,p<0.01), and posteromedial direction (**r=.353**,p<0.05).For the anterolateral direction a positive correlation was found with Anteromedial direction (**r=.711**,p<0.01), and a negative correlation with Medial direction (**r=-.367**,p<0.05).Medial direction showed positive correlation with each one of lateral direction (**r=.690**,p<0.01), posterior direction (**r=.592**,p<0.01), Posterolateral direction (**r=.351**,p<0.05), and posteromedial direction (**r=.363**,p<0.05). Lateral direction correlated with pain thresholds (**r=.354**, p<0.05), pain tolerance (**r=.434**, p<0.01), medial direction (**r=.690**, p<0.01), posterior direction (**r=.686**, p<0.01), Posterolateral direction (**r=.626**, p<0.01), and posteromedial direction (**r=496**, p<0.01).

Posterior direction correlated with pain tolerance (**r=.341**, p<0.05), medial direction (**r=.592**, p<0.01), lateral direction (**r=.686**, p<0.01), Posterolateral direction (**r=.638**, p<0.01) and posteromedial direction (**r=.475**, p<0.01). And a correlation of Posterolateral direction with pain tolerance (**r=.394**, p<0.01), medial direction (**r=.35**, p<0.05), lateral direction (**r=.626**, p<0.01), and posterior (**r=.638**, p<0.01), and posteromedial direction (**r=.649**, p<0.01). While posteromedial direction correlated with medial direction (**r=.363**, p<0.05), lateral direction (**r=.496**, p<0.01), posterior direction (**r=.475**, p<0.01), and Posterolateral direction (**r=.649**, p<0.01). But SLST did not show any correlational status with any of the other variables.

Table26: Pearson Correlation

Dominant Side Pain Perception, Proprioception, Dynamic Balance and Static Balance for Non-Athletes:

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	*	.907**	-.239	-.067	-.126	-.157	-.018	-.124	-.043	-.048	.069	-.170	-.061
2		*	-.188	-.182	-.143	-.138	-.121	-.190	-.148	-.099	.121	-.156	-.202
3			*	.199	-.421	-.185	.036	.162	.143	-.044	-.276	-.046	-.263
4				*	.116	.064	.053	.089	.414	.095	.259	.343	.472*
5					*	.268	.060	.176	.352	-.098	.343	.536*	-.123
6						*	.615**	.269	.173	.215	.134	.246	.095
7							*	.480*	.384	.425	.089	.394	-.112
8								*	.643**	.489*	.138	.585**	-.020
9									*	.305	.217	.469*	.053
10										*	.376	.414	-.017
11											*	.595**	.022
12												*	-.065
13													*

**p<0,01 , *p<0,05, 1=Pain Th. , 2=Pain T., 3=AAE Ankle DF, 4= AAE Ankle PF, 5=Ant, 6=AntLat, 7=AntMed, 8=Med , 9=Lat , 10=Post , 11=PostLat , 12=PostMed ,13=SLST.

5. DISCUSSION

The main objectives of the current study were to compare between athletic and non-athletic healthy subjects in terms of pain perception, ankle joint and foot articulation proprioception, and balance. Also it aims to understand the correlation between those variables. According to current knowledge there is no study discussing the nature of correlational relationship of those variables together.

In the present study first assessed variable was pain perception presented as pain thresholds and pain tolerance ratings. A significant difference was found between groups regarding pain thresholds and pain tolerance ratings on both right and left sides. As athletes showed higher results for pain thresholds and pain tolerance ratings on both left and right sides when compared to non-athletes.

Ryan, E. D., & Kovacic, C. R in a study investigating the effect of athletic participation on pressure pain and ischemic pain, among contact sport athletes group, non-contact sport athletes group and control group. A significant difference was found among groups in pain threshold and pain tolerance scores. [60]

These differences have been referred to many reasons: **Non-nociceptive afferents activation** (Golgi tendon organs and muscle spindles) during and following exercise, which can modify the activity of nociceptive afferents, leading to decreased pain perception. [3]

Elevations in blood pressure, or the stimulation of arterial baroreceptors, inhibit pain in humans. Because systolic blood pressure is increased during exercise and baroreceptors are stimulated, it is plausible that analgesia during or following exercise results from overlapping pain and cardiovascular regulatory mechanisms. [18]

Also a significant difference was found in pain ratings of threshold and tolerance when compared in terms of gender as males showed always higher scores of pain than females. This supports the results of Bek, N., Uygur, F.study which was aiming to investigate age and gender differences in pressure pain threshold (PPTh) and pressure pain tolerance (PPTo), found that PPTo was significantly higher in males, both in the older and younger groups. [61]

Discussing the results many researchers suggest that these differences between males and females in pain rating are due to many physiological and psychological causes. In one of those studies there were typical sex differences in blood pressure, and blood pressure reactivity was positively related to duration of the painful stimulus. Also theysuggested that body size had significant effects on blood pressure, but there was also a relation with reported pain [62.63]. On the other hand weight showed a relation with perceived pain intensity. So, it is possible that greater body mass in males works as an insulating factor, which in turn leads to reduced perceived pain intensity (pain perception).

As stated before the first part of proprioception assessment, which was sense of motion of the first and fifth metatarsophalangeal joints a significant difference was found between groups only among planter flexion and dorsiflexion of 1st metatarsophalangeal joints, meanwhile there were no differences among 5th metatarsophalangeal joints as all participants were able to recognize the direction of joint movement.

On the other hand the results of active angle reproduction test for ankle joint showed significant difference between athletes and non-athletes for both ankle planter-flexion and ankle dorsiflexion.

Supporting the finding of the current study, a positive relationship was mentioned by many articles where various types of sports showed high effects on the proprioceptive skills of ankle joint with significant differences between athletes and non-athletes.

Han, J. and Anson, J assessed proprioception at the knee, and shoulder in addition to the ankle. Of these three critical body sites the ankle, shoulder, and knee ankle proprioception was correlated most strongly with sport competition level and was the most significant illustrative factor of the physical performance for athletes.[64]

Han, J. and Anson, J in a study concerned about both active and passive sense of position for ankle joint found that gymnasts were markedly better able to reproduce passive and active positioning of angles of the ankle for both motions of inversion and plantar flexion when compared to the ability of controls.[65]

Some published works showed that exercise can improve proprioception, especially proprioceptive exercise which depends on the presence of three actions: the proprioception of the joints, balance capacity, and neuromuscular control. [14]

Particularly, long-term Tai Chi practice was found to be beneficial at proprioception improvement of the lower limbs. [66]

On the other hand Schmitt, H. and Kuni, B in a study about the effect of 5 months of professional dance training program did not show any improvement of the ankle joint position sense or improved measures of balance.[67] This leads to the point that exercise type and duration has an important role in the improvement of joint position sense.

Moreover, considering the comparison of proprioception in terms of gender, our recent study showed a meaningful relationship between gender and proprioceptive skills of the ankle and metatarsophalangeal joints

Although Muaidi, Qassim in astudy that aims to check whether proprioceptive acuity in knee internal and external rotation is significantly different between men and women. They found the women generally had lower proprioception acuity in IR than men. [68]

Nagai, T., Sell, T in a study aimed to determine if gender differences exist in the precision of knee internal and external rotation threshold to detect passive motion. Females demonstrated significantly diminished (TTDPM) toward internal rotation only; no other significant differences were found. [68]

In the review of literature they referred these results mainly to the differences to gender's influence on ligaments volume (number of mechanoreceptors per gram of specimen weight) which are generally lower in women than men, assuming that this is the main cause in such difference in proprioceptive accuracy between genders, that also leads to a highly increased rate of injury in women during sport performance. Even though there were no such significant results in the current study but we can still say that males had slightly performed better in this part.

Also for the assessment of balance in this study two tests were used, star excursion balance test for dynamic balance, and the single leg standing test for static balance. In the dynamic balance athletes performed highly better than non-athletes with a significant difference except one direction which was (Anteromedial), but there was no significant difference between genders with both groups, mentioning that males generally performed better than females without showing such a significant difference. Moreover no significant differences were found regarding static balance between athletes and non-athletes as well as between males and females.

Same results were found in a previous study by Pandey, A. and Venugopal, R.that aimed to compare dynamic balance between athletes and non-athletes using Star Excursion Balance test (SEBT), it showed significant difference ($p<.05$) in dynamic balance on dominant limb between athletes and non-athletes. Moreover similar results were found for static balance when comparing athletic gymnastics to non-athletes using flamingo test. [69,70]

One more study that supports the results of the current study, Sabin, M. and Ebersole, K. compared between athletes basketball players and non-athletes and found a significant difference in all directions of star excursion balance test. [71]

On the other hand comparison of both static and dynamic balance in terms of gender did not show such a significant difference; mentioning that males had slightly performed better in both star excursion test and single leg standing test.

Same study by Sabin, M. and Ebersole, K also aimed to examine SEBT performance in both stable and unstable surfaces among basketball players, didn't show significant differences between genders except in one direction of the SEBT -the posterior direction-[71] , in addition to another previous study by Bryant, E. C., Trew, M. E aiming to investigate whether any gender differences exist in balance performance showed no differences were found in static balance performance between men and women [72],which supports the findings of the current study.

6.CONCLUSION

In a conclusion of the current study, we might say that regular athletic performance affected positively on pain perception, joint sense of motion (proprioception) and dynamic balance as athletes preformed significantly better than non-athletes. Meanwhile static balance showed not to be affected with athletic performance as there was no significant differences between athletes and non-athletes.

Same results were found when those variables were compared in terms of gender, as pain perception, proprioception and dynamic balance showed to be affected with gender, while static balance didn't show any relation. Other finding of this research suggested that there is no meaningful relation between any variable and the other.

Future studies might consider including a larger sample size of participants and using another digital tool for assessing pain perception might be useful, also for proprioception measurement, future studies might consider in using computer-based tools for better assessment results and for better outcome.

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Appendix A: Ethical Committee Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1845 **09/04/2020**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Amani Altaee)

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü Prof. Dr. Rasmi Muammer'in sorumlu araştırmacı olduğu **"Relationship Of Sensory Perception , Proprioception Of Foot and Balance Among Athletic and Non-Athletic Healthy Subjects''** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(1828)** kayıt Numaralı KAEK Başvuru Dosyası, Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **08.04.2020** tarihli toplantıda incelenmiştir.

Sağlık Bakanlığı'nın Covid-19 pandemisi nedeniyle uygulamakta olduğu ''toplumsal izolasyon veya karantina'' uygulamalarının bitiminde başlanması şartıyla;

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 1186**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Appendix B: Participant constant from (English)

Title of Study: Relationship of Sensory Perception, proprioception of ankle, and Balance among athletic and non-athletic healthy subjects.

Investigator: Name: Amani AlTaee **Dept.** Physiotherapy **phone** 05388215279

Introduction

• You are being asked to be in a research study of assessment of a group of physical variables and how they might affect each other.

• We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study

- The purpose of this investigation is to examine the relationship between pain perception and sense of position of foot and ankle, and Balance.
- Ultimately, this research will be used for Master degree thesis and may be used in external publications

Description of the Study Procedures

• This research is targeting athletes and non-athletes aged between 19-30 years, data will be collected from 42 participant between 30Feb and 30March 2020.

• You will take part in one of the two groups in this study (athlete or not athlete) according to your criteria.

• Weight and height will be noted.

• We will start with measuring pain perception with (pressure pain type) over foot sole using a Baseline Dolorimeter.

• Balance will be assessed using the pro-kin system for dynamic balance.

• Ability to differentiate position sense of foot and ankle will be assessed with a manual angle reproduction test.

• The procedure will be conducted by a physical therapist in the physiotherapy laboratory.

• The procedure time will be approximately 20 / 35 minutes.

Risks/Discomforts of Being in this Study

• There are no reasonable foreseeable (or expected) risks. There may be unknown risks.

• Due to the nature of the approach that works on muscles a slight discomfort might occur.

Confidentiality

• This study is anonymous. We will not be collecting or retaining any information about your identity.

• The records of this study will be kept strictly confidential. Research records will be kept in a locked file and all electronic information will be coded and secured using a password protected file. We will not include any information in any report we may publish that would make it possible to identify you.

Right to Refuse or Withdraw

• The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or the institution. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

• You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me (Amani AlTaee) at (amanitaee1995@gmail.com).or by telephone at 05388215279 If you like, a summary of the results of the study will be sent to you. If you have any problems or concerns that occur as a result of your participation, you can report them to the investigator at the number above.

Consent

• Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators

Subject's name ______________________

Signature ___________________________

Investigator's name ____________________

Signature __________________________________

Appendix C: Participant constant from (Turkish)

Çalışmanın adı: Atletik ve Atletik Olmayan Sağlıklı Denekler Arasında Duyusal Algı, Ayak ve Ayak Bileği Propriyosepsiyonu ve Denge Arasındaki İlişki.

Araştırmacı İsim: Amani AlTaee **Bölümü:** fizyoterapi **Tele:**05388215279

Giriş:

• Bir grup fiziksel değişkeni ve bunların birbirlerini nasıl etkileyebileceğini değerlendiren bir araştırma çalışmasında bulunmanız istenir.

• Çalışmayı kabul etmeden önce bu formu okumanızı ve sorularınızı sormanızı rica ediyoruz.

Çalışmanın amacı:

• Bu araştırmanın amacı ağrı algısı ile ayak ve ayak bileği pozisyonu, ve Denge arasındaki ilişkiyi incelemektir.

• Sonuç olarak, bu araştırma Yüksek lisans tezi için kullanılacak ve harici yayınlarda kullanılabilecektir.

Çalışma Prosedürlerinin Tanımı

• Bu araştırma 19-30 yaş arası sporcuları ve sporcu olmayanları hedeflemektedir, 30 Şubat ve 30 Mart 2020 tarihleri arasında 42 katılımcıdan veri toplanacaktır.

• Bu çalışmadaki iki gruptan birine (atlet ya da atlet değil) kriterlerinize göre katılacaksınız.

• Ağırlık ve yükseklik not edilecektir.

• Bir algometri kullanarak ayak tabanı üzerinde (basınç ağrı tipi) ile ağrı algısının ölçülmesiyle başlayacağız.

• Denge, dinamik denge için pro-kin sistemi kullanılarak değerlendirilecektir.

• Ayak ve ayak bileği pozisyonu hissini ayırt edebilme yeteneği, gonyometre kullanılarak manuel bir yöntemle değerlendirilecektir.

• İşlem fizyoterapi laboratuvarında bir fizyoterapist tarafından yapılacaktır.

• Prosedür süresi yaklaşık 20/35 dakika olacaktır.

Bu Çalışmada Olmanın Riskleri / Rahatsızlıklar:

• Öngörülebilir (veya beklenen) herhangi bir makul risk yoktur. Bilinmeyen riskler olabilir.

• Kaslar üzerinde çalışan yaklaşımın doğası gereği hafif bir rahatsızlık oluşabilir.

Gizlilik:

• Bu çalışma anonimdir. Kimliğiniz hakkında herhangi bir bilgi toplamayacağız veya saklamayacağız.

• Bu çalışmanın kayıtları kesinlikle gizli tutulacaktır. Araştırma kayıtları kilitli bir dosyada saklanacak ve tüm elektronik bilgiler şifre korumalı bir dosya kullanılarak kodlanacak ve güvence altına alınacaktır. Yayınlayabileceğimiz hiçbir raporu, sizi tanımayı mümkün kılacak hiçbir bilgiyi eklemeyeceğiz.

Reddetme veya Geri Çekme Hakkı:

• Bu çalışmaya katılma kararı tamamen size kalmış. Bu araştırmanın veya kurumun araştırmacıları ile ilişkinizi etkilemeden, herhangi bir zamanda çalışmaya katılmayı reddedebilirsiniz. Süreç boyunca herhangi bir noktada tek bir soruya cevap vermeme ve görüşmeden tamamen geri çekilme hakkına sahipsiniz; ayrıca, görüşmeciden görüşme materyallerinizi kullanmamasını talep etme hakkına sahipsiniz.

Soru Sorma ve Endişeleri Bildirme Hakkı:

• Bu araştırma çalışması hakkında soru sorma ve bu soruları araştırma öncesinde, sırasında veya sonrasında yanımda cevaplama hakkına sahipsiniz. Çalışma hakkında başka sorularınız varsa, (amanitaee1995@gmail.com) adresinden benimle (Amani Altaee) iletişime geçmekten çekinmeyin. sana gönderildi. Katılımınızın bir sonucu olarak ortaya çıkan herhangi bir sorun veya endişeniz varsa, bunları yukarıdaki numaradan araştırmacıya bildirebilirsiniz.

Razı olmak:

• Aşağıdaki imzanız, bu çalışma için araştırma katılımcısı olarak gönüllü olmaya karar verdiğinizi ve yukarıda verilen bilgileri okuduğunuzu ve anladığınızı gösterir. Çalışma araştırmacıları tarafından gerekli görülen diğer basılı materyallerin yanı sıra bu formun imzalı ve tarihli bir kopyası size verilecektir.

Konu adı ______________________
İmza ___________________________
Araştırmacı adı ____________________
İmza ______________________________

Appendix D: Data collection form

Relation between Sensory Perception, Proprioception of Foot and Ankle, and Balance among Athletic and Non-athletic Healthy Subjects.

- Participant's name:
- Phone:
- Age:
- Gender:
- Dominant side: left right
- Group: athlete non-athlete
- **If athlete**

Type of sport	
Years of practice	
Days	
Hours	

- **Body Mass Index:**

Weight (Kg)	Height (cm)	BMI (kg/m^2)

1. PAIN PERCEPTION:

RIGHT

	1^{st}metatarsal	5^{th}metatarsal	Heel
Pain threshold	kg	kg	kg
Pain tolerance	kg	Kg	kg

LFFT

	1^{st}metatarsal	5^{th}metatarsal	Heel
Pain threshold	Kg	kg	kg
Pain tolerance	kg	kg	kg

2. **Proprioception:**

- **Joint position sense:**

Right ankle joint:

	Ankle DF +10	Ankle PF +15
Perceived angle	**1st trial** °	**1st trial** °
	2nd trial °	**2nd trial** °
	3rd trial °	**3rd trial** °
mean	°	°

Left ankle joint:

	Ankle DF +10	Ankle PF +15
Perceived angle	**1st trial** °	**1st trial** °
	2nd trial °	**2nd trial** °
	3rd trial °	**3rd trial** °
mean	°	°

- **Motion sense (movements of up and down, eyes closed):**

First Metatarsophalangeal joint:

	Right limb
1st trial	Yes / No
2nd trial	Yes / No
3rd trial	Yes / No

	left limb
1st trial	Yes / No
2nd trial	Yes / No
3rd trial	Yes / No

Fifth Metatarsophalangeal joint:

	Right limb
1st trial	Yes / No
2nd trial	Yes / No
3rd trial	Yes / No

	left limb
1st trial	Yes / No
2nd trial	Yes / No
3rd trial	Yes / No

3. **Balance:**

- **Single leg standing test:**

Side	time
Right	
Left	

- **star excursion balance test :** leg length: (   )

	RIGHT mean	**LEFT mean**
Anterior		
Anterolateral		
Anteromedial		
Medial		
Lateral		
Posterior		
Posterolateral		
Posteromedial		

APPENDIX E: Curriculum Vitae

Personal Informations:

Name	Amani Altaee	**Surname**	Altaee
Place of Birth		**Date of Birth**	24.09.1995
Nationality		**TR ID Number**	
E-mail		**Phone number**	

Education

Degree	Department	The name of the Institution Graduated From	Graduation year
Master	Physiotherapy and Rehabilitation	Yeditepe University	2021
University	General Physiotherapy	Alazhar University of Gaza AUG	2017
High school	General Sciences	American International School of Gaza AISG	2013

Languages	Grades (#))
IELETS	6

#All the grades must be listed if there is more than one (KPDS, ÜDS, TOEFL; EELTS vs),

Work Experience (Sort from present to past)

Position	Institute	Duration (Year - Year)
Physiotherapist	Alnour Medical Center	2017-2018
		-

Computer Skills

Program	Level

***Excellent , good, average or basic**

Scientific works

The articles published in the journals indexed bySCI, SSCI, AHCI

Articles published in other journals

Proceedings presented in international scientific meetings and published in proceedings book.

Journals in the proceedings book of the refereed conference / symposium

Others (Projects / Certificates / Rewards)
