Original Article

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Effect of Central Fatigue on Dynamic Balance and Knee Joint Proprioception in Recreational Athletes: An Experimental Study

Physiotherapy Section

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ABSTRACT

Introduction: The salient constituent of physical activity is fatigue that can influence execution of sports as well as it can also affect the activities of daily living. Abundant conventions are being used to magnify the fatigue, resisting dimension of the individual but none has proven to be effective. Therefore, this research will give perception about the central fatigue, that can affect dynamic balance and knee joint proprioception in healthy individuals. This can further be related in athletes also; in designing their training protocol to minimise the fatigue level and thus enhancing the performance of an individual.

Aim: To study the effect of central fatigue on dynamic balance and knee joint proprioception in recreational athletes.

Materials and Methods: This experimental study was conducted at the Department of Physiotherapy, Faculty of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India from 25th March 2022 to 25th June 2022. Twenty-five subjects were recruited in the study on the basis of inclusion and exclusion criteria. Star Excursion Balance Test (SEBT) and proprioception were measured before and after inducing central fatigue. The paired t-test was used to compare pre and post values of SEBT and proprioception.

Results: There was significant effect of central fatigue in different excursion reach of dynamic balance from pre to post, anteromedial (p-value <0.001), medial (p-value <0.001), posterolateral (p-value <0.001), lateral (p-value <0.001) and anterolateral (p-value <0.001) directions. In addition, the knee joint proprioception was significantly reduced following central fatigue was initiated.

Conclusion: Dynamic balance and knee joint proprioception reduced when the individual was undergoing central fatigue.

Keywords: Beep test, Joint position sense, Start excursion balance test

INTRODUCTION

Fatigue is one of the most common components in individuals suffering from chronic illnesses. Fatigue can be of two types i.e., central or peripheral. Peripheral fatigue refers to exercise-induced processes that lead to a reduction in force production and that occur at or distal to the neuromuscular junction. Central fatigue is a developing movement-persuaded non fulfillment of discretionary initiation of the muscle and it can be signified by an expansion in the augmentation in strength called up by stimulation of the nerve throughout a paramount voluntary attempt [1,2]. Both central and peripheral fatigue mature gradually throughout submaximal exercises. Severe exercises, which cause muscle fatigue, may have an impact on joint proprioception and increase knee anterior posterior laxity. Thacker SB et al., stated that muscle fatigue and poor proprioception increase joint laxity and may lead to knee injury [3]. Mild exercise will improve proprioception senses and postural control which will prevent the impairment [4,5]. Mechanisms that originate fatigue are dependent on task. Fatigue includes intensity and type of exercise, load, and particular muscle group tested physical conditions and duty cycle.

The capability to maintain firmness within the base of support is known as balance [5]. Injuries can be prevented by improving joint proprioception and balance control. Physiology beyond the fatigue-mediated variations in the knee neuromuscular control is yet to be determined. Knee joint proprioception with interchange in lower limb motor control has an influence on each other due to neuromuscular fatigue [6,7]. Muscle receptors, primarily muscle spindles and golgi tendon organs have considerable benefaction to position sense and kinaesthesia [8,9]. Fatigue conventions would probably influence muscle tissue more than joint tissue. Recurrent or assisted fibrous activity and is familiar with movement and Activities of Daily Living (ADL) results in fatigue in healthy individuals. In clinical practice, fatigue seems to be a frequent complaint of patients suffering from neuromuscular disorders in healthy people fatigue. In the previous studies there was a statistically significant reduction in the ability of the subjects to reproduce the same angle at the knee joint after a fatigue protocol which was reflected as an increase in the degree of angulations from an average of 2.90° to 3.97° [10]. Fatigue protocol have influenced assisted motion kinaesthesia abilities in subjects, the same was indicated as a reduction in the average angle from 1.20° to 0.84° at the knee joint, whereas the researcher were not able to establish the results significantly [10]. The part for both muscular and capsular receptors in knee joint proprioception was initiated by few authors may be more predominant in joint position sense, as the fatigue convention may have exhausted the receptors of the muscle more than the receptors of the joint [9]. Fatigue induced by general exercises such as cycling or running better resembles conditions in daily life and physical activities induced by exercising the lower extremities isolated in an isokinetic device. Isokinetic or isometric contraction exercises are often used to fatigue muscles. These activities are usually not functional or direct sport activity related. Isokinetic exercise is used to provide objective measure of muscle's ability to generate force [11]. There is dearth of the study on the recreational athletes.

Therefore, the aim of the present study was to study the effect of central fatigue on dynamic balance and knee joint proprioception in recreational athletes.

MATERIALS AND METHODS

This experimental study with a single group was conducted at the Department of Physiotherapy, Faculty of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India, from 25th March 2022 to 25th June 2022. The ethical approval has been taken from Institutional Ethical Committee (Approval No. EC/2022-23/015).

Inclusion criteria: Twenty five participants with age between 18-25 years, both males and females recreational athletes were included in the study.

Exclusion criteria: Individual with any musculoskletal disorder (joint pathology, lower extremity injury for <3 months), neurological disorder and biomechanical aberration of lower extremity were excluded from the study. Also, if the individual was found to have fatigue less than 5 out of 10 in rate of perceived exertion (RPE) were also excluded from the study.

Sample size calculation: To examine the effect of fatigue on dynamic balance and proprioception in recreational athletes, a posthoc power analysis was conducted for sample size of 25, using G.Power 3.1.9.4. Based on the changes in SEBT in anteromedial direction after inducing fatigue, the effect size observed in the present findings was 0.996.

Participants were explained about the procedure individually and informed consent form was signed. All the uncertainties among the participants were cleared about the procedure. Outcome measures were assessed before inducing fatigue and after fatigue protocol. Fatigue was induced using beep test protocol. Outcome measures were proprioception by reposition error test and dynamic balance by star excursion balance test (SEBT) [12,13].

Study Procedure

Participants were instructed to perform warm up on static cycle for five minutes. Central fatigue was induced by administering beep test, as it has been considered as a most reliable method [14]. It is a multistage fitness test protocol, which includes running 20 metre distance using maximal aerobic fitness, commonly known as 20-metre shuttle test or beep test. The subjects were asked to continuously run between two cones kept 20 m apart in recorded time after every beep. The subjects were asked to stand behind the cone facing the second and start running when hearing the beep sound. Initially the speed of the intermittent beep is slow. The subject was asked to maintain running between two cones, and try to reach the cone before the next beep. As the test progresses the duration between each beep is reduced and as a result the subject has to increase the running speed. If the person reaches the cone before the beep he has to wait until hearing the next beep. The duration between every beep is reduced every minute. If the subject fails to reach the cone for three consecutive beeps it was considered the end of the test and the level of the beep was noted for further calculation. In such case it is considered that the subject is fatigued.

Participants reported their perceived level of exertion using the RPE scale at each progressive level of the beep test. It is used for estimating effort, exertion, breathlessness and fatigue during physical workout [12]. The RPE scale, numbers from 0-10 was used. The numbers that are provided below indicates the rate of ease or difficult level of an activity. 0 (nothing at all) indicates how you feel while sitting on a chair and 10 (very very heavy) indicates how you feel after the end of the difficult activity.0- Nothing at all, 0.5- Just noticeable, 1- Very light, 2- Light, 3- Moderate, 4- Somewhat heavy, 5-6 Heavy, 7-9 Very heavy, 10- Very, very heavy.

Outcome Measures

Dynamic balance was assessed by SEBT. Subjects were given practice trials before the start of the test to get familiar with the procedure of test through a verbal and visual demonstration followed by a rest of two minutes. To initiate testing, subjects were standing on one leg at the centre of the "star" with both hands on the waist and reached with the opposite leg in a particular direction as far as possible, touching the lines with toes. After each trial, subjects then returned to the starting position [Table/Fig-1]. Test was performed in all directions (anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral) [13]. Total three trials were done in respective direction and best of the three readings was taken as final reading. Trial was discarded and repeated if the assessor observes that (1) lifted or moved stance foot from the centre of grid (2) failed to maintain the unilateral stance and (3) failed to touch the line with reach foot, keeping complete weight bearing on the stance foot. Reach distance were normalised to limb length using the formula, maximised reach distance=(reach distance/leg length)×100.

[Table/Fig-1]: Measurement of reach distance, during performance of star excursion balance test.

Knee joint proprioception was assessed by angle reposition error method using goniometer. A little more than an inch above the knee joint line, the goniometer was fastened to the distal thigh. To remove the visual cures, the patient was made to stand up against the wall while being blindfolded [Table/Fig-2]. Then the patient was asked to squat to 30 degrees of knee flexion and maintain and remember the position for 15 seconds and return to starting position i.e., 0 degree knee extension [15,16].

[Table/Fig-2]: Measurement of knee proprioception using reposition error test.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for the Social Sciences (SPSS) version 21.0. The Shapiro-Wilk test was used to verify the normality of distribution for all variables. All the data was found to be normally distributed. Paired t-test was used to analyse changes within the group (before and after fatigue protocol). The level of significance for statistical tests was set at p-value≤0.05 with confidence interval 95%.

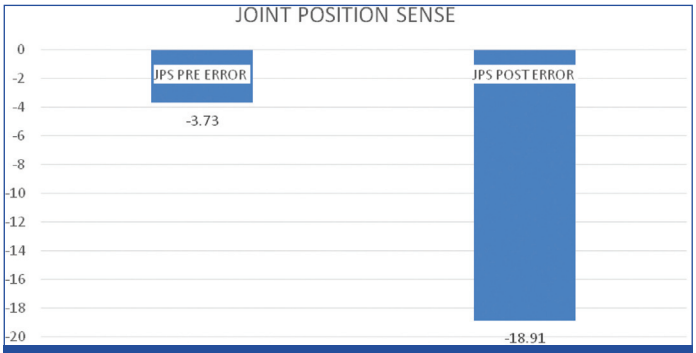
RESULTS

The result showed that there was significant difference found between before and after inducing central fatigue for SEBT in anterior (t=14.31, p-value <0.001), anteromedial (t=4.9, p-value <0.001, medial (t=5.15, p-value <0.001), posteromedial (t=5.18, p-value <0.001), posterior (t=8.71, p-value <0.001), posterolateral (t=7.76, p-value <0.001), lateral (t=14.2, p-value <0.001) and anterolateral (t=5.47, p-value <0.001) [Table/Fig-3].

In addition, in the knee joint proprioception significant difference was found following central fatigue (t=12, p-value <0.001) between before measurement (-3.73±2.65) and after measurement (-18.91±5.53) of knee joint proprioception in [Table/Fig-4].

Variables	Before fatigue (N=25) Mean±SD	After fatigue (N=25) Mean±SD	t-value	p-value
Star excursion balance test				
Anterior	82.15±9.25	65.73±8.15	14.31	<0.001*
Anteromedial	70.07±8.75	61.75±6.81	4.92	<0.001*
Medial	65.63±0.05	62.59±7.93	5.15	<0.001*
Posteromedial	70.22±8.62	62.59±7.93	5.18	<0.001*
Posterior	72.64±7.67	53.45±9.68	8.71	<0.001*
Posterolateral	61.68±7.26	53.70±7.01	7.76	<0.001*
Lateral	72.04±7.67	49.13±7.58	14.2	<0.001*
Anterolateral	70.38±9.02	60.88±7.17	5.47	<0.001*

[Table/Fig-3]: Measures of star excursion balance test in all directions before and after inducing central fatigue.
*Paired t test significance difference



[Table/Fig-4]: Knee joint reposition error measures before and after induction of central fatigue.

DISCUSSION

In the present study, it has been found that there are significant changes in all the directions of SEBT i.e., anterior, anteromedial, anterolateral, medial, posterior, posterolateral, lateral and posteromedial. Also, proprioception reposition error was found to be increased after central fatigue protocol.

The present study's result was found in consistent with the previous studies showing localised fatigue affect the static balance [17]. Other study also showed that both general and local fatigue impairs static balance, but they found that general fatigue show greater decrease in static balance than local fatigue [18]. Our result was consistent with some researchers, while others reported that fatigue had a significant effect on the dynamic balance of athletes [19,20] and recreational athletes [21]. However, one study showed fatigue had no effect on dynamic balance in athletes [22].

These results can be due to physiological theories of balance which states that athlete playing multiple sports disturbed their equilibrium to a near maximum as they choose different movement trajectories in an attempt to obtain a maximum reach distance. Balance has been discovered to be of utmost importance in sports, not only for injury rehabilitation but also for injury prevention [23,24]. Dynamic balance is more significant in prevention of injury during sporting activity as it is being constantly challenged during sports performance and hence need to be near normal for prevention of occurrence of any injury [25].

Focus of any sports activity or any training protocol is to improve an individual player's balance. As far as balance is concerned it has been seen that multiple sports provides relatively greater challenge to limits of balance as compared to single sport. It was suggested that individuals playing single sports should incorporate multiple recreational activities during their training program to improve their dynamic balance while keeping focus on their single sport alongside. This will not only improve their performance in sports but also provide greater chances of prevention of injury as a post to the situation where they are playing and training only one sporting activity. This was shown in study by Plisky PJ et al., in high school basketball players [23]. In addition, they found that the SEBT may possibly predict lower extremity injury among high school basketball players. Hertel J et al., worked on simplifying the SEBT by analysing the subjects with and without ankle instability and they investigated that the posteromedial reach direction seems to be the most indicative of the overall performance of the SEBT in limbs with and without chronic ankle instability [26].

Perceived exertion scale specifies how vigorous a person feels their body is working. A person's heart rate elevates, their muscles tire, they breathe harder, and they perspire during a physical activity. All of these give rise to the sense of exertion. The rating of perceived exertion, or RPE, is a scale that estimates a person's heart rate based on how hard they feel they are working. Heart rates may change considerably depending on age of the person and fitness level. May be the subjects were not fully fatigued when they have complained of fatigue. Many subjects got fatigued in the familiarisation. Rate of perceived exertion is a very subjective measure every individual has different perception accordingly. Mechanism of central fatigue is loss of recruitment of high threshold motor units, reduced central drive from increased inhibitory interneuron input to motor cortex, central conduction block from demyelination or motor neuron drop out, increased negative feedback from muscle afferent types third and fourth sensory neurons, loss of positive feedback from muscle spindle type 1 sensory afference [27]. It has been confirmed that proprioceptive sense is moderated through joint and muscle receptors. Evidence recommends the joint and muscle receptors mediate swaps in the efferent output of the muscles that control the knee, which possibly allows stability and stiffness to the knee. The neuromuscular control of the limb is compromised in the state of altered efferent input as well as during fatigue, which may lead to incapacity to dynamically support the knee [27-30]. For more clear distinction, the fatigue induced influence of laxity of knee joint on proprioception needs to be studied.

Limitation(s)

Equal numbers of male and female subjects were not included in the study. Intervention or any type of training was not performed. However, specific instrumentation for balance testing like force platform can be performed.

CONCLUSION(S)

When someone is experiencing fatigue, their dynamic balance decreases or becomes uneven and there is increased in joint position sense error. Therefore, the central fatigue has a relationship with dynamic balance and knee joint position sense.

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