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ORIGINAL RESEARCH

THE ROLE OF LEG AND TRUNK MUSCLES PROPRIOCEPTION ON STATIC AND DYNAMIC POSTURAL CONTROL

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Abstract
The proprioception information is a prerequisite for balance, body's navigation system, and the movement coordinator. Due to changes between the angles of ankle, knee, and hip joints the aforementioned information are important in the coordination of the limbs and postural balance. The aim of this study was to investigate the role of leg and trunk muscles proprioception on static and dynamic postural control. Thirty males students of physical education and sport sciences (age =21.23 ± 2.95 years, height = 170.4 ± 5.1 cm, and weight = 70.7 ± 5.6 kg) participated in this study volunteered. Vibration (100HZ) was used to disturb of proprioception. Vibration operated on leg muscle (gasterocnemius) and trunk muscles (erector spine muscle, at L1 level). Leg stance time and Star Excursion Balance Test were used for evaluation of static and dynamic postural control respectively. Subjects performed pre and post (with operated vibration) leg stance time and star excursion balance test. Paired sample test used for investigation the effect of vibration on leg and trunk muscles in static and dynamic postural control. Result of this study showed in static postural control, there is no significant difference between pre and post test (operated vibration) in leg and trunk muscles ($p \leq 0.05$). In contrast there is significant difference in dynamic postural control between pre and post test in leg muscles in 8 directions of star excursion balance test ($p \leq 0.05$) while there is only significant difference in trunk muscle in antrolateral and lateral of star excursion balance test ($p \leq 0.05$). During physical training such conditions like fatigue and injury can disturb proprioceptions' information. Thus, due to the importance of this information we recommend that coaches' additionally specific trainings any sport used specific exercises to enhance the proprioception information.
Key words: Vibration, postural control, Proprioception, Leg and trunk muscle.
The running head: Role of Leg and Trunk Muscles Proprioception on Postural Control

Introduction

Aspects of neuromuscular control may be quantified through measures of postural control. Postural control can be defined as either static (maintaining a position with minimal movement), semi-dynamic (maintaining a position while the base of support moves), or dynamic (maintaining a stable base of support while completing a prescribed movement) (Winter et al, 1990).
In order to produce appropriate force, and control the balance in a timely manner the central nervous (CNS) system requires the exact position of the body in space both in stationary and dynamic situations. The CNS must coordinate the incoming information from the sensory receptors in order to identify the body's position in space (Akuthotaet al, 2004). Body's movements and its position in space in relation to its surroundings are detected naturally by several means such as vision, somatosensory sensations (deep, subcutaneous receptors, joints and muscles), and vestibular which are then interpreted by the CNS. Each one of these sensational systems relay

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specific information about the body's position in space; therefore, each system acts as an independent information centre for the CNS (Akuthotaet al,2004).
Vision is responsible for the head's position and movement in relation to the surrounding objects. Via various directional head movements the distance between objects, head and eyes are detectable with the vision system. Information acquired via vision is important for maintaining balance (Akuthotaet al, 2004). The somatosensory system relays the relevant information about body movements in space in relation to a stable surface to the CNS. In addition, the somatosensory system detects the relationship between the various limbs in the body. The receptors of this system include muscle spindles, Golgi tendon organs, joint receptors, and subcutaneous receptors (i.e., vibration, touch, pressure and stretch sensations) (Capicikova et al, 2006).
The human balance control system aimed at the achievement of two behavioral goals: postural orientation and postural equilibrium (Horak et al, 1996 and Richard et al., 2005). Postural orientation refers to the position of the body with respect to gravitational vertical and it is characterized by body tilts from the vertical position. Postural equilibrium refers to body balance around equilibrium point, i.e. the configuration where all forces acting on the body are balanced in the desired body vertical position (Hay et al, 1996).
Proprioceptive inputs from postural muscles, particularly from leg postural muscles, are important information in human postural control (Rogers et al, 1985). The balance control process can be influenced by vibratory stimulation of postural muscles (Rogers et al, 1985). Vibration of leg postural muscles evokes kinesthetic illusion of movement in standing subjects and it results in a postural response known as vibratory induced falling (Eklund, 1973). The induced body tilt can be characterized as involuntary body lean in the direction of vibrated muscles (Hayashi et al, 1981). Vibration applied to a muscle increases the firing of muscle spindles which inform the central nervous system that the muscle is being stretched (Roll et al, 1989).
Vibration almost selectively activates the primary terminations of the muscle spindle, very much as a tendon tap does (Roll et al, 1989). Continuous muscle vibration has powerful effects on upright stance that are partly connected to the subject's reactions to the illusions of movement produced by vibration (Roll et al, 1989). During stepping-in-place, hamstring muscles vibration produces involuntary forward stepping, and during treadmill locomotion involuntary step-like increase of walking speed (Ivanenco et al, 1999). During blindfolded walking, minor though significant changes in kinematics of lower limb segment are induced by bilateral continuous vibration of the extensor muscles of the legs (Biguer et al, 1988). Symmetrical vibration, though, can give no information on potential effects on the orientation of the locomotors path. In the case of neck muscle, asymmetrical vibration induces displacement of the subjective straight-ahead (Biguer et al, 1988) and trajectory deviation during walking or body rotation during stepping-in-place, both opposite to the vibration side (Biguer et al, 1988). Therefore, the aim of this study was to investigate the role of leg and trunk muscles proprioception on static and dynamic postural control

Methods

Thirty males students of physical education and sport sciences from Guilan University (age =21.23 ± 2.95 years, height = 170.4 ± 5.1 cm, and weight = 70.7 ± 5.6 kg) participated in this study volunteered. All volunteers were healthy without experiencing any difficulties in their balance. To ensure that subjects were all healthy and without any previous injuries a health questionnaire was filled by each subject. After completing the consent form, the experiment was explained in details to the subjects. A vibration device was used to disturb the proprioception. This specific vibration device (100 Hz) was made by an Iranian company to fulfill the goals of this experiment. For disturbtion of proprioception the vibration was imposed on the erector spine muscle, at L1 level, about 5cm from the midline and leg muscles. To access the dynamic and static postural control star excursion balance test and leg stance time were utilized. After familiarization with the tests, subjects warm up for 5 minutes prior to the actual test. The warm up consisted of specific stretching routine for the following lower body muscles: hamstrings, gracilis, gluteus, quadriceps, and soleus.

Star excursion balance test

This is a test that incorporates a single-leg stance on one leg with maximum reach of the opposite leg. The test is consisted of 8 lines that make a 45 degree angle to one another. The 45 degree increments are from the center of the grid. The 8 lines positioned on the grid are labelled according to the direction of excursion relative to the stance leg (anterior, anterolateral, anteromedial, medial, lateral, posterior, posterolateral, posteromedial) (Blackburn et al, 2000). The diameter of the circle is 182/9 cm, and it is placed on a firm surface. The width of each line is 7/62 cm. In order to reduce the learning effect each subject choose 6 directions out of the 8 to practice (Kinzey et al, 1998).The subject stood in the middle of the circle with the dominant leg; then with the opposite leg he reached for the furthest marked distance (Figure 1). Each subject was asked to touch the furthest part of the line with the most distal part of his reach foot. This was done with control and in a slow manner to ensure adequate neuromuscular control of the stance leg. The subject then returned to the original stance and the touch points that were marked during examination were recorded. Three second rest were allocated between each reach. The direction of the revolution based on the right or left reach legs was clock wise and counter clock wise, respectively (Kinzey et al, 1998). The reach was not accepted if the leg could not touch the target line, if

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the subject's weight was shifted to the reach leg, if the support leg was lifted from the center, or if balance was disturbed during the reach (Kinzey et al, 1998).

Figure1. a subject performing the posterior-reach component of the Star Excursion Balance Tests.

Single leg stance

Subject stand on one leg, his or her arms place across his or her chest with his or her hands touching her or his shoulders and his or her legs don't touch each other. Subject should look straight ahead with his or her eyes open and focus on an object about 3 feet in front of him. Ideally do this with the shoes off. The *Criteria to stop timing the test contain of:* The legs touched each other, the feet moved on the floor, their foot touches down, or the arms moved from their start position.

Results

Result of this study showed in static postural control, there is no significant difference between pre and post test (operated vibration) in leg and trunk muscles (table 1). In contrast there is significant difference in dynamic postural control between pre and post test in leg muscles in 8 directions of star excursion balance test (table 2) while there is only significant difference in trunk muscle in antrolateral and lateral of star excursion balance test (figure 2).

Table1.results of t test for cooperation pre and post test in leg stance time in second

Groups muscles	**Mean Standard Deviation**	***t***	**Degree of freedom**	***p***
Leg muscles	Pre-test19.23±6.67 Pre-test 14.26 ± 5.21	*-1.25*	*29*	*0.09*
Trunk extensor muscles	Pre-test20.15±7.31 Pre-test 16.64 ± 6.25	*-1.12*	*29*	*0.12*

Table 2.The results for the *t* test correlation with respect to the reached distance in centimetre for pre and post test (with vibration) in dynamic balance.

Directions of SEBT	Mean Standard Deviation	*t*	Degree of freedom	*p*
Anterior	Pre-test 85.25 ± 5.3 Post-test 83.4 ± 6.2	1.21	29	0.08
Anteromedial	Pre-test 91.32±5.4 Post-test 89.1 ± 5.9	1.2	29	0.09
Medial	Pre-test 91.4 ± 7.6 Post-test 89.4 ± 6.5	1.33	29	0.12
Posteromedial	Pre-test 99.1 ± 8.1 Post-test 97.3 ± 7.6	1.41	29	0.08
Posterior	Pre-test 95.4 ± 9.7 Post-test 92.47± 8.3	1.7	29	0.1
Posterolateral	Pre-test 92.4 ± 8.7 Post-test 90.12± 10.12	1.25	29	0.09
Lateral	Pre-test 61.23 ± 8.1 Post-test 55.3± 7.2	2.66	29	0,03*
Anterolateral	Pre-test 88.9 ± 7.5 Post-test 73.2 ± 7.4	3.51	29	0.001*

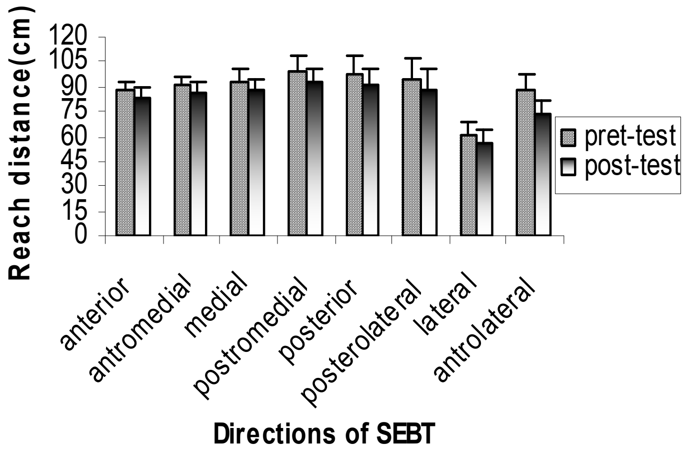

*Figure 2.*The mean comparison of the pre and post test for the distance in the eight directions of the dynamic balance in trunk extensor muscles

Discussion

The purpose of this study was to evaluate the role of leg and trunk muscles proprioception in static and dynamic postural controll. The Result of this study showed in static postural control, there is no significant difference between pre and post test (operated vibration) in leg and trunk muscles. In contrast there is significant difference in dynamic postural control between pre and post test in leg muscles in 8 directions of star excursion balance testwhile there is only significant difference in trunk muscle in antrolateral and lateral of star excursion balance test. Many studies have analyzed the sensory adjustments and coordination in the movement control (Susco et al, 2005, Karnath et al, 2002) and the consensus is that the information is integrated cumulatively. Therefore, disturbed leg muscle information could be one method of proprioception interpretation; as a result it could cause an error in the superior system. During movement this error could cause deviation from the path; this previously has been demonstrated by the non-continues stimulation of the neck muscles (Susco et al., 2005; Karnath et al, 2002, Mergner et al, 1997).

In postural control involves vision, vestibular and somatosensory systems. The defection in any system results in disturbing of balance but if the defection compensate by other system, person may maintaining his or her balance. It seems that in static postural control because person has minimum movement in his or her base of support, the defection create in balance by vibration, compensate by other system then, there was no significant difference between pre and post test in static postural control. In general the proprioception information is a prerequisite for balance, body's navigation system, and the movement coordinator (Bove et al, 2001). Due to changes between the angles of ankle, knee, and hip joints the aforementioned information are important in the coordination of the limbs and postural balance. In fact human body uses the proprioception information in order to respond to the changes in body's position (Bove et al, 2001). Thus, disturbances in this information in any form or shape cause disruption in balance (Kavounoudias et al, 1999). It seems that changes in the entrance of afferent sensory pathways cause changes in the control of the lower body muscles. Additionally, it is known that changes in entrances of afferent from the receptors in the muscle causes reduced ability of the control over the lower body limbs (Ashton-Miller et al, 2001). Inability of nervous system to relay signals is due to the muscles' inability to respond to the stimuli. Vibration could possibly influence the receptors and causes change in the motor path way and in turn control the posture. It seems that vibration influences the muscular tissue more than joints' receptors and the activities of the proprioception such as muscle spindles and Golgi tendon organs are reduced. Possibly this nervous/muscular deficiency on muscular control of the lower body has a negative effect on the ability to reach the marked distance; as a result the reach is reduced in post-test compared to the pre-test.

Conclusion

With regards to the results of this research, it seems that vibration can have a disturbing effect on dynamic posture and this point demonstrate how important the proprioceptions' information of the leg and trunk muscles are in the control of dynamic posture. During physical training such conditions like fatigue (Nicolas et al, 2007) and injury (Amy et al, 2005) can disturb proprioceptions' information. Thus, due to the importance of this information in the control of the dynamic balance, we recommend that coaches use specific exercises to enhance the proprioception information. Although it is not realistic to expect a coach to stop practice or decrease practice times because someone is experiencing fatigue which may lead to injury, this topic needs attention. To be realistic, most coaches could rearrange how practices are conducted. For example, a coach who is having three hour gymnastic practices could schedule the more difficult and higher risk activities in the first half of practice and leave the lower risk activities for the last hour when the athletes will be feeling the effects of fatigue.

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