

ORIGINAL PAPER (ARTIGO ORIGINAL)

THE EFFECTS OF ACTIVITY RELATED FATIGUE ON STATIC AND DYNAMIC POSTURAL CONTROL IN COLLEGE ATHLETES

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ABSTRACT

HOSSEINIMEHR, S. H; DANESHMANDI, H; NORASTEH, A. A. The effects of activity related fatigue on static and dynamic postural control in college athletes. *Brazilian Journal of Biomotricity*, v. 4, n. 2, p. 148-155, 2010. The purpose of this study was to investigate the effects of activity related fatigue on static and dynamic postural control in college athletes. Thirty college athletes (15 males, 15 females, age = 22.32 ± 0.92 years, height = 169.5 ± 5.7 cm, and weight = 64.2 ± 3.4 kg) participated in this study voluntary. Leg stance time and Star Excursion Balance Test were used for evaluation of static and dynamic postural control, respectively. Subjects performed a functional fatigued protocol that lasted 15 minutes. Using the Borg scale, also measured rating of perceived exertion before, middle and after the fatigue protocol. Repeated measure (1x3) ANOVA and post-hoc (LSD) was used for comparison of difference in fatigue reported scores. Paired sample test was used for comparison of difference between pre and post test in static and dynamic postural control. The findings indicated that dynamic postural control decreased after fatigue ($P < 0.05$), in contrast there is no significant difference between pre and post test in static postural control ($P < 0.05$). 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.

Key words: Fatigue, Dynamic and static postural control, Star excursion balance test, Leg stance time.

INTRODUCTION

Balance plays a curtail role in almost all sport events. Either in shooting which requires the least amount of movements, or dynamic sports such as gymnastics and wrestling, which require agility in conjunction with maximum balance, balance plays a critical role in success and failure (HOSSEINIMEHR et al., 2009). 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) (GRIBBLE et al, 2004).

The muscular fatigue (MF) that is defined as any reduction in the neuromuscular ability to produce strength (ROZZI et al., 2000) is a usual phenomenon in resistance sports, and is a common experience in the daily activities (JOHNSTON et al., 1998). The beginning of the voluntary muscular activity involves several processes that start with the cortical control in the brain, and end with the cross-bridges inside the muscular fiber. Therefore, the muscular fatigue can be the result of a failure in any process involved in the muscular contraction (JOHNSTON et al., 1998). Until recently, most research completed on proprioception and the lower extremity examined balance or joint position sense (NAKAGAVA et al., 2004). These studies often examined proprioception of the ankle and/or knee during an injured state, or evaluated the benefits of balance training when rehabilitating an injury (NAKAGAVA et al., 2004). More recently, fatigue has become a popular focus of research, examining fatigue and the relationship to ankle sprains (NAKAGAVA et al., 2004, GRIBBLE et al, 2004, HOSTON et al., 2005) and knee injuries (HIEMSTRA et al., 2001, SKINNER et al., 1986, ROWE et al., 1999) with regard to altered postural control. Gribble and Hertel (2004) examined this further as they conducted a study on how fatiguing various muscles of the lower extremity (flexors and extensors of the hip and knee, and dorsiflexors and plantarflexors of subtalar joint) affected static postural stability as measured by a static unilateral leg stance (GRIBBLE et al, 2004). They found that fatiguing muscles more proximally altered static postural control more than fatiguing the more distal muscles (GRIBBLE et al, 2004). Other problem with the current research is that it often uses a repeated isokinetic exercise, or an isometric hold to fatigue the muscle or muscles being examined. Although an easy standardized way to fatigue a muscle or muscle group, these activities are usually not functional or sport related in anyway. However, there are few times in any sport where a player will be standing in a static isometric plantarflexed position until they can not hold it anymore, and then play in a game. Since researchers have been able to develop this vast base of support knowledge in this area, it is time to take the next step. Research needs to support a more functional or sport-related fatiguing protocol, to observe how the rigors of athletic competition affects static and dynamic postural control system of the body. There is a need to determine if the coordinated movements involved in sports along with cardiovascular endurance combine to produce a different level of fatigue that can have a detrimental effect on dynamic postural control. It appears that with the lack of current research linking static and dynamic postural control and fatigue, and the current concepts in rehabilitation that one would want to examine the possible connection between overall body fatigue and how it interacts with static and dynamic postural control. Also, a majority of these fatiguing studies have evaluated static postural control (NAKAGAVA et al., 2004, GRIBBLE et al, 2004, HOSTON et al., 2005) or joint position sense at the ankle with or without a fatiguing protocol (HIENSTRA et al., 2001, SKINNER et al., 1986, ROWE et al., 1999). Therefore the purpose of this study is to examine the effects of an activity related fatiguing protocol fatigue on static and dynamic postural control.

METHOD

Subjects

Thirty physical education students from Guilan University (15 males, 15 females, age = 22.32 ± 0.92 years, height = 169.5 ± 5.7 cm, and weight = 64.2 ± 3.4 kg) volunteered as subjects. Individuals with self-reported vestibular disorders or mild head injury in the



previous 6 months were excluded from the study. All volunteers were 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.

Procedure

To access the dynamic and static postural control star excursion balance test and leg stance time were utilized. subjects warm up for 5 minutes prior to the actual test after familiarization with the tests. 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) (KINZEY et al., 1998). 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 chooses 6 directions out of the 8 to practice (BLACKBUM et al., 2000). 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 (BLACKBUM et al., 2000). The reach was not accepted if the leg could not touch the target line, if 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 (BLACKBUM et al., 2000).



Figure 1 - A subject performing the posterior-reach component of the Star Excursion Balance Test.

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.

Fatigue protocol

The fatiguing protocol consisted of seven stations each designed to fatigue the subject by using different energy systems to represent a sport-related fatigue. Each station was timed by Triathlon watch. Just prior to the first station, the principal investigator took the Rating of Perceived Exertion (RPE) (SUSCO et al., 2004) reading from the participant. Station one consisted of a five-minute moderate Jog at the subjects self-selected pace. This jog took place around the perimeter of the gym in order to help the participant maintain a steady pace. Station two consisted of two minutes of sprints up and down the length of a basketball court. Station three was one minute of push-ups. After station three was completed, the RPE measurement was taken as station three is considered the half-way point. Station four consisted of 1.5 minutes of sit-ups. Station five was two minutes of 12 inch step-ups. Station six consisted of another two minutes of sprints up and down the basketball court, and station seven was 1.5 minutes run at as fast a pace as the participant could maintain for the entire 1.5 minutes (SUSCO et al., 2004, WILKINZ et al., 2004). A third RPE was recorded as soon as the subject completed the last station. Adequate fatigue has been deemed to be an RPE of 15 which represents 75% to 90% maximum oxygen consumption WILKINZ et al., 2004, NICOLAS et al., 2005) immediately after taking the RPE; the subject completed the post-test (post-fatigue).

Statistically analyses

A one-way repeated measures ANOVA was used to determine if a difference existed for Rating of Perceived Exertion. Post-hoc testing consisted of three pairwise comparisons (pre-test to mid-test, pre-test to post-test, and mid-test to post-test) to determine which changes were significant. Paired sample test was used for comparison of difference between pre and post test in static and dynamic postural control. The p value for all tests was set at $p < 0.05$.

RESULTS

Repeated measured (1×3) ANOVA showed there was significant difference for RPE ($F_{1,29} = 4182.31$, $P < .001$). also post-hoc (LSD) showed that pre-test to mid-test ($P < 0.001$), pre-test to post-test ($P < 0.001$), and mid-test to post-test ($P < .001$) were all statistically significant. The t test correlation between the pre and post test showed that fatigue resulted in a meaningful reduction in the reached distance of all eight directions of the dynamic balance (Table 1 & Figure 2). In contrast, there was no significant difference between pre and post test in static postural control (Table 2).

Table 1 - The results for the t test correlation with respect to the reached distance in centimetre for pre and post test in dynamic balance.

Directions of SEBT	Mean	Standard Deviation	t	Degree of freedom	p
Anterior	Pre-test	88.23 ± 5.8	2.32	29	0.03
	Post-test	83.8 ± 6.3			
Anteromedial	Pre-test	90.23±5.3	2.6	29	0.01
	Post-test	85.12 ± 5.3			
Medial	Pre-test	91.45 ± 5.12	2.51	29	0.01
	Post-test	88.3 ± 5.4			
Posteromedial	Pre-test	99.3 ± 7.6	2.4	29	0.001
	Post-test	91.12 ± 5.9			
Posterior	Pre-test	97.4 ± 8.1	2.54	29	0.01
	Post-test	91.25± 8.2			
Posterolateral	Pre-test	96.14 ± 7.8	3.24	29	0.001
	Post-test	89.3± 8.1			
Lateral	Pre-test	61.13 ± 8.4	2.54	29	0.01
	Post-test	55 .5± 6.5			
Anterolateral	Pre-test	88.25 ± 7.2	4.32	29	0.001
	Post-test	74.1 ± 7.8			

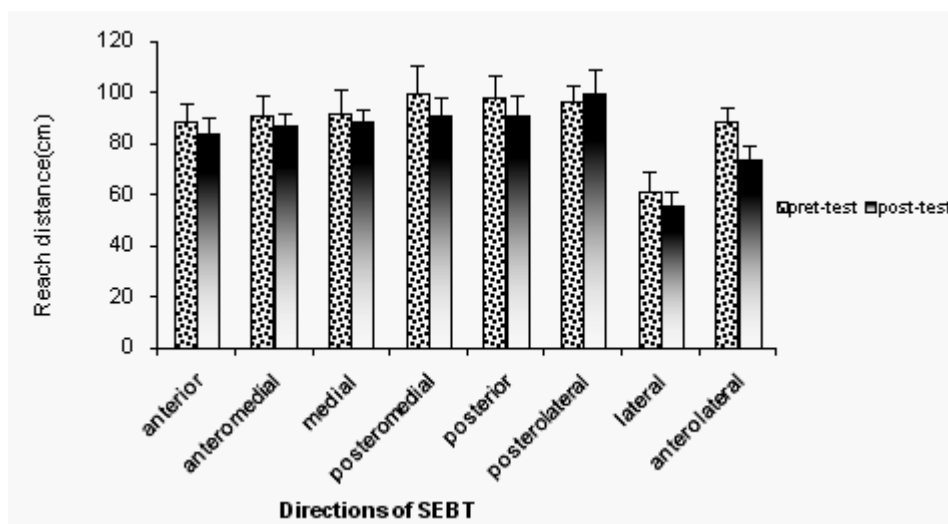


Figure 2 - The mean comparison of the pre and post test for the distance in the eight directions of the dynamic postural control.

Table 2 - Results of t test for cooperation pre and post test in leg stance time in second

	Mean Standard Deviation	t	Degree of freedom	p
Pre-test	19.23±5.62	-1.42	29	0.09
Post-test	12.15±5.43			

DISCUSSION

To begin the discussion, it must be known that this study is the first to report on an activity related fatiguing protocol on static and dynamic postural control in college athletes. A majority of other fatiguing studies have evaluated static postural control (NAKAGAVA et al., 2004, GRIBBLE et al, 2004, HOSTON et al., 2005) or joint position sense at the ankle with or without a fatiguing protocol (HIEMSTRA et al., 2001, SKINNER et al., 1986, ROWE et al., 1999). These studies that used a local fatiguing protocol followed either an isokinetic fatiguing protocol, a repeated lifting protocol, or an isometric fatiguing protocol. Few studies, if any exist in the literature that use a central or general fatigue protocol to evaluate static and dynamic postural control. Lepers et al (2002) used a cycling bout protocol, but did not examine dynamic postural control. Susco et al (2004) and Wilkins et al (2004) used this functional fatiguing protocol, but evaluated the subject's performance on the Balance Error Scoring System (BESS), a measure of static balance.

Although recently there has been extensive research on fatigue and dynamic postural control as measured by the Star Excursion Balance Test (SEBT), there is limited research available examining a sport-related fatiguing process and the effects it would have on static and dynamic postural control? An activity related fatiguing process would involve an exercise e bout that would more closely resemble a "typical" practice or game and would fatigue both local and central processes instead of just concentrating on a single muscle or muscle group. This fatiguing process would include various types of exercise in an attempt to fatigue the athlete including but not limited to isokinetic exercise, isotonic exercise, plyometric and agility exercises, as well as testing their cardiovascular endurance. One of the factors in developing and designing a central or general fatiguing protocol is that it actually is taxing to all energy systems. Although fatigue substrates and metabolites were not determined in this study or the Wilkins et al (2004) or Susco et al (2004) Studies, Susco et al. determined that an activity of this nature does cause fatigue and that fatigue lasts at least twenty minutes. The post-test SEBT took on average 10 minutes to complete, with the longest time being 13 minutes. If one considers the 20 minute fatigue time span in the Susco et al. study, the participants should still have been fatigued and were still reporting feelings of fatigue. To ensure fatigue occurred in all three studies, the rating of perceived exertion was used to determine the participant's level of fatigue. Proprioception is the specialized variation of the sensory modality of touch that encompasses the sensation of joint movement. The application of proprioception requires afferent information from the many mechanoreceptors like the muscle spindles, golgi tendon organs, Ruffini endings, Pacinian Corpuscles, and cutaneous receptors.

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 fatigue, 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 (NICOLAS et al., 2005). 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. Thus, disturbances in this information in any form or shape causes disruption in balance (NICOLAS et al., 2005).

CONCLUSION

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.

REFERENCES

- BLACKBUM, T.; GUAKIEWICZ, K. M.; PETSCHAUR, M. A.; PRENTICE, W. E. Balance and joint stability: the relative contributions of proprioception and muscular strength. *Journal of Sport Rehabilitation*, v. 9, p. 315-328, 2000.
- GRIBBLE, P. A.; HERTEL, J. Effect of lower-extremity muscle fatigue on postural control. *Journal of Archives of Physical Medicine and Rehabilitation*, v. 85, p. 589-592, 2004.
- HIEMSTRA, L. A.; LO, I. K.; FOWLER, P. J. Effect of fatigue on knee proprioception: implications for dynamic stabilization, *Journal of Orthopaedical Sports Physical Therapy*, v. 31, p. 598-605, 2001.
- HOSSEINIMEHR, S. H.; NORASTEH, A. A.; DANESHMANDI, H.; RAHPEMAY-RAD, K.; RAHIMI, R. The effect of vibration on leg muscles proprioception in static and dynamic postural control, *Journal of Medicina dello Sport*, v. 62 p. 35-43, 2009.
- HUSTON, J. L.; SANDREY, M. A.; LIVELY, M. W.; KOTSKO, K. The effects of calf-muscle fatigue on sagittal-plane joint-position sense in the ankle. *Journal of Sport Rehabilitation*, v. 14, p. 168-184, 2005.
- JOHNSTON, R. B.; HOWARD, M. E.; CAWLEY, P. W.; LOSSEE, G. M. Effect of lower extremity muscular fatigue on motor control performance, *Medicine and Science in Sports and Exercise*, v. 30, p. 1703–1707, 1998.
- KINZEY, S. J.; ARMSTRONG, C. W. The reliability of the star-excursion test in assessing dynamic balance, *Journal of Orthopaedical Sports Physical Therapy*, v. 27, p. 356-360, 1998.
- LEPRES, R.; MAFFIULETTI, N.; ROCHETTE, L.; BRUGNIAUX, J.; MILLET, F. Neuromuscular fatigue during a long-duration cycling exercise, *Journal of Applied Physiology*, v. 92, p. 1487-1493, 2002.
- NAKAGAWA, L.; HOFFMAN, M. Performance in static, dynamic, and clinical tests of postural control in individuals with recurrent ankle sprains. *Journal of Sport Rehabilitation*, v. 13, p. 255-268, 2004.
- NICOLAS, V.; NICOLAS, P. Postural control during quiet standing following cervical muscular fatigue: effect of changes in sensory inputs. *Journal of Neuroscience Letters*, v.

63, p. 135-139, 2005 .

ROWE, A.; WRIGHT, S.; NYLAND, J.; CABOM, D. N. M.; KLING, R. Effects of a 2-hour cheerleading practice on dynamic postural stability, knee laxity, and hamstring extensibility. *Journal of Orthopaedical Sports Physical Therapy*, v. 29, p. 455-462, 1999.

ROZZI, S.; YUKTANANDANA, P.; PINCIVERO, D.; LEPHART, S. Role of fatigue on proprioception and neuromuscular control. In: Lephart S, Fu F, eds. *Proprioception and Neuromuscular Control in Joint Stability*. Champaign, IL: Human Kinetics, p. 375–383, 2000.

SKINNER, H. B.; WYATT, M. P.; HODGDON, J. A.; CONRAD, D. W.; BARRACK, R. L. Effect of fatigue on joint position sense of the knee. *Journal of Orthopaedical Sports Physical Therapy*, v. 4, p. 112-118, 1986.

SUSCO, T. M.; MCLEOD, T. C. V.; GANSNEDER, B. M.; SHULTZ, S. J. Balance recovers within 20 minutes after exertion as measured by the balance error scoring system, *Journal of Athletic Training*, v. 39, p. 241-246, 2004.

WILKINS, J. C.; MCLEOD, T. C. V.; PERRIN, D. H.; GANSNEDER, B. M. Performance on the balance error scoring system decreases after fatigue, *Journal of Athletic Training*, v. 39, p.156-161, 2004.

WINTER, D. A.; PATLA, A. E.; FRANK, J. S. Assessment of balance control in humans. *Medical Progress Through Technology*, v. 16, p. 31–51, 1990.