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A Study on the Effects of General Fatigue on Head and Neck Proprioception in Healthy Young Adults

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SUMMARY

Background. Fatigue is one of the factors causing disturbance in proprioception which can be manifested in two ways: general and local. Due to the important role of cervical proprioception on body stability and posture, research on the effects of general fatigue on proprioception helps to better understand its mechanism and to improve the strategies to prevent injury. Therefore, the aim of this study was to identify the effects of general fatigue on head and neck proprioception in young healthy adults.

Material and methods. This clinical study was done by implementing pre- and post-test measurements in 112 young healthy subjects aged between 18-30 years and able to walk at a speed of 10Km for 5 minutes. They were randomly divided into an experimental and control group. The patients in the control (not exposed to a general fatigue task) and experimental (exposed to a general fatigue task) groups were matched for age, height and weight. In the first step, the zero absolute reposition angle of the head and neck was measured in all participants. Then the subjects in the experimental group did a five-minute run on the treadmill to achieve the level of general fatigue, following which the head and neck reproduction angle was measured in all subjects for the second time.

Results. There was a statistical significant difference between pre- and post-test absolute angular error in the experimental group; however, there was no noticeable difference between the pre- and post-test data in the control group.

Conclusions. 1. General fatigue increased the repositioning angular error of head and neck. 2. Neck proprioception decreased due to general fatigue. 3. General fatigue increased the risk of neck injury.

Key words: general fatigue, head and neck, proprioception

BACKGROUND

Proprioception plays an important role to provide for local and general stability, as well as postural control of human body. Various factors have a significant influence on proprioception, including pain and fatigue [1-5]. The head and neck provide important sets of proprioception information required for controlling stability. The proprioceptors of the neck, responsible for proprioception, have two major roles. The first role is to provide some information about positions and movements of the cervical spine for the central nervous system. The second role relates to initiating spinal reflexes used to enhance stability and protection of the human body. Based on the results of various studies, neck muscle proprioception has a significant role in maintaining proper orientation, balance and motor coordination of the body. Several factors have been reported to influence cervical proprioception, including trauma, general and local muscular fatigue and aging. There is a significant relationship between fatigue and proprioception [3,6-14]. In contrast, some studies report no association between proprioception and the absolute reproduction angle error following fatigue [15]. Based on the available literature, it is controversial whether there is an association between fatigue and altered proprioception of the cervical spine. There is no doubt that the proprioception of cervical spine plays an important role in controlling body movements. Therefore any mechanism influencing the proprioception of the cervical spine will affect the performance of subjects during standing and walking and finally will influence the risk of injuries. The lack of information in this regard prompted us to evaluate the association between fatigue and alteration of proprioception of the cervical spine. The main hypothesis associated with this study was that there would be a considerable relationship between fatigue and alteration of proprioception of the cervical spine. The results of our study not only elucidate the mechanism of influence of fatigue on posture and movement control, but also show the importance of evaluation of head and neck proprioception in occupational and sports activities, or for therapeutic purposes.

MATERIAL AND METHODS

A case-control design was used in this study. 112 normal subjects were recruited from male and female students of Isfahan University of Medical Sciences, aged 18-30 years. An ethical approval was obtained from the Shahid Beheshti University of Medical Sciences. Every subject was asked to sign a consent form before data collection. The subjects were randomly assigned to either a control or experimental group (56 for each group). Table 1 shows the characteristics of the subjects participating in this study.

The inclusion criteria of this study were:

1. Age between 18-30 years
2. Able to walk on an inclined treadmill at a speed of 10 km/h for 5 minutes
3. No history of regular and professional sports activities for at least 6 months preceding the study

The exclusion criteria for all subjects were: Cardiovascular, pulmonary, neurological, musculoskeletal disorders, diabetes, and any lower limb pathologies which influence the walking performance of the subjects.

Research procedure: First, the error in head and neck proprioception was measured by repositioning angle method. Measuring the repositioning angle error was done according to the method of Revel and Roven [16,17]. A helmet was placed on the subject head and fixed in place by the helmet's belt. A laser pointer was affixed firmly on top of the helmet in order to monitor the head and neck movements on a scaled board installed on the opposite wall in front of the subject at a distance of 90 cm from the laser pointer. The subject was asked to sit comfortably on the armchair, with the trunk firmly fixed and supported. Figure 1 shows the position of the subject in this study.

The subjects were blind-folded, with the head fixed in a neutral position. The scaled board was fixed and calibrated each time to have the laser pointer on the Zero point. This position was held by subjects for 3 seconds in order for them to memorize the start position. Next, the examiner passively rotated the subjects' head maximally to the right at a constant speed, and immediately returned the head to the target angle (zero point). Then the subjects were asked to turn their heads actively to the right and reproduce the target angle. The examiner recorded the position of the point without giving any feedback to the subjects. The distance between the registered point and target point (RT) was calculated on the board. The repositioning angle error was calculated based on the following equation:

$$\theta(\deg ree) = A\tan(\frac{RT}{RH})*180/3.14$$

In which, RT is the distance between the registered point and target point on the board and RH is the distance between the laser pointer and target point on the board.

The subjects reproduced the target angle three times, and the average repositioning angle error of

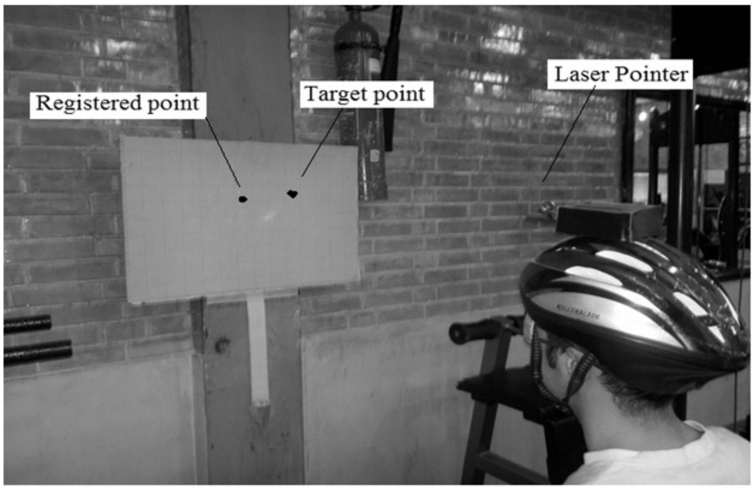

Figure 1. Repositioning angle measurement

Figure 2. General fatigue protocol on a treadmill

the three attempts was assumed as the main repositioning angle error. The repositioning angle error was registered as absolute error without considering the direction of the error.

In the experimental group, a 5-minute general fatigue protocol was performed and the repositioning angle error reevaluated. General fatigue was produced only in the subjects of the experimental group according to the protocol of Miura et al. The subjects ran on a treadmill at the speed of 10 km/h with a 10% uphill angle, for 5 minutes. If the heart rate of a subject exceeded the maximum of 86% of the high threshold (220 – age), they were asked to stop running [18,19].

In the control group, subjects were given 5 minutes' rest followed by reevaluation of the repositioning angle error.

The mean values of the pre- and post-test repositioning angular error were compared in the experimental and control groups by means of the paired t test with the statistical significance threshold set at 0.05.

RESULTS

There was no significant difference between the groups in terms of sex ratio, age, height, and weight. The mean values of the repositioning angular error in the control group were 6.4±2.86 degrees and 5.9±2.57 degrees for the first and second tests, respectively (p-value=0.18). The corresponding values in the

Table 1. The characteristics of the subjects participating in this study

	Number	Age (years)	Height (m)	Weight (kg)
Experimental group	56	24.3±3.8	1.785±0.12	62.4±6.2
Control group	56	23.9±4.2	1.76±0.17	64.1±3.9

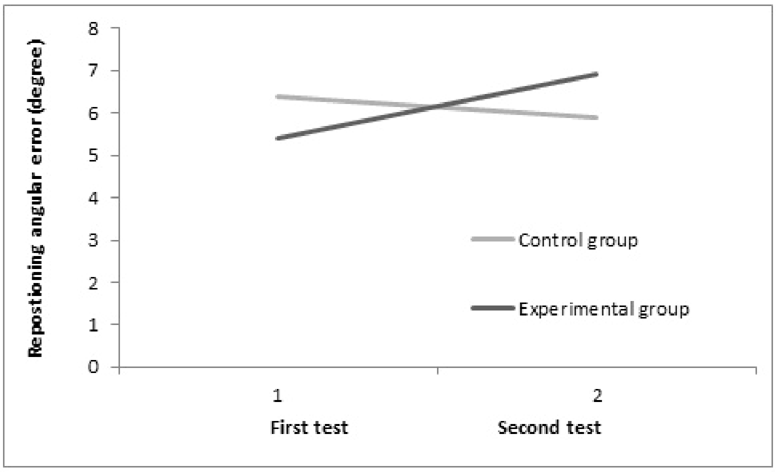

Figure 3. Comparison between the repositioning angular error of first and second tests in both groups

experimental group were 5.4±2.56 for the first test and 6.9±2.56 for the second test (p-value= 0.0015). Figure 3 shows a comparison between the repositioning angular error of the first and second tests in both groups.

DISCUSSION

The main purpose of this study was to evaluate the effect of general fatigue on head and neck proprioception in healthy young adults. Based on the results of this study, the absolute repositioning error measured for the second time after 5 minutes' rest in the control group demonstrated no statistical significant change. This means that, without an intervention, head and neck proprioception does not change. Moreover, according to the results, not only the second values in the control group did not increase, but also there was a decrease from 6.4 to 5.9. Although this reduction was not significant, it could be related to a learning effect in the angle repositioning test due to repetition.

Bayramoglu found that the repositioning angle error decreased without any intervention. They also believed that the decrease was due to a learning effect and that it was more evident when there were more repetitions [20].

In the experimental group, after the intervention, there was a statistically significant increase in the absolute repositioning angle error from 5.4±2.56 to 6.9±2.56 when general fatigue had been produced. According to these results, we can conclude that general fatigue can increase the zero repositioning angle error or the neutral position of the head and neck in young and healthy people by 1.5 degree. The findings of the present study are consistent with those of Miura [21].

Another study examining the effect of general fatigue on proprioception was done by Bazrafkan et al. They investigated the effect of general fatigue produced by running on a treadmill on elbow muscle proprioception by analyzing the force sense error. They reported proprioception disturbance due to fatigue as a result of running on a treadmill. Although the error value of local fatigue was higher, there was no significant difference between the two methods [22].

In present study, the mean head and neck repositioning error in healthy young subjects was 5.9 degrees, exceeding the values obtained in other studies, which reported error values of 2.5-4.5 degrees [15, 23-26].

A similar difference was reported in a study by Pinsault. He believed these differences were mostly due to different research methods used in different studies [26]. He referred to the value reported by Roven and Revel, which was 4.5 degrees. However, Revel and Roven in their studies express higher values of 4.5 degree which is not safe proprioception for patients with neck pain [16,17]. Many other scientists have reported values of repositioning error of less than 4 degrees in groups of patients suffering from neck pain [27-30]. Considering the increase of the head and neck proprioception error due to general fatigue and also the importance of proprioception for postural control and joint stability, it can be concluded that general fatigue can increase the risk of musculoskeletal injuries. Therefore, in addition to local fatigue-producing factors and ways of preventing them and reducing injury risk in occupational and sports fields, the effects of general fatigue on musculoskeletal injury must be considered, together with appropriate strategies to prevent these problems. This means that in addition to emphasis on local fatigue, attention should be drawn to general fatigue because it can increase the risk of injury. The results of this study can be used in occupational and sports environments. They are also useful for planning strategies for preventing musculoskeletal injury.

There is a limitation which should be acknowledged in this study. Only healthy young subjects were recruited in this study. It is recommended that in future studies the effects of general fatigue be studied on young and elderly healthy individuals and patients.

CONCLUSIONS

1. General fatigue increased the repositioning angular error of head and neck
2. Neck proprioception decreased due to general fatigue
3. General fatigue increased the risk of neck injury

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