Research Paper: Comparing the Effect of Fatigue on Choice Reaction Time of Healthy Men and Women

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ABSTRACT

Purpose: Reaction time is a good indicator of coordination between sensory motion and individual performance. It is the time interval from perceiving sudden stimulus until the reaction to that stimulus. One of the factors affecting reaction time is fatigue. Considering the different characteristics of fatigue in men and women, this study aimed to compare the effect of fatigue on the choice reaction time between men and women.

Methods: The present study has quasi-experimental design with pretest and posttest. A total of 16 healthy men and 16 healthy women within the age range of 18 to 35 years participated in this study. For measuring the reaction time and fatigue, 4-choice reaction time test and Borg Scale were used, respectively. To induce muscle fatigue, the stretch-shortening cycle protocol, which involves consecutive jumps in repetitive short and ascending cycles were used. When the participants' attempts score to perform the protocol reached 15 or more, execution of the protocol was terminated and the test of the choice reaction time was administered using visual stimulus. Reaction time was recorded in both modes before and after the fatigue. Descriptive statistics (mean and standard deviation), and inferential statistics (correlated t test and covariance analysis) were used to analyze the obtained data. Statistical analyses were performed with SPSS 19.

Results: There was no significant difference between the choice reaction time of men and women before and after fatigue (P>0.05). Although, after fatigue, the mean score of the participants' reaction time increased in both men and women groups, this difference was not statistically significant.

Conclusion: Fatigue had no significant impact on the choice reaction time of non-athlete healthy men and women. And despite different fatigue characteristics in men and women, no difference was observed in the choice reaction time between two groups. It seems that the exhaustion perceived by the participants was the result of peripheral fatigue, not central fatigue.

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1. Introduction

Reaction time is a proper indicator to assess the speed of the central nervous system processing and coordination between the sensory and motor systems [1]. The reaction time is the interval from perceiving sudden stimulus until the reaction to that stimulus [2]. The reaction time in the choice mode has more application compared to simple mode in everyday activities and is considered a better predictor of disability [3]. It is a very sensitive parameter and represents the motor and cognitive function of the individual. It has been used in many studies on motor control and attention level [4, 5]. Several factors like age, gender, fatigue, degree of arousal, type of stimulus, number of stimuli, compatibility of response stimulus, nutrition, and drug and alcohol use, affect reaction time [6].

Fatigue is one of the important and influential factors in processing information that affects the afferent and efferent systems [7-10]. It is defined as the reduction of power generation and inability to sustain the production of power for continuing the activity [11], and has two types of local (peripheral) and general (central) [12, 13]. Local fatigue emerges in muscles and involves a particular group of muscles and may lead to disorders at the location of muscle and nerve connective tissue; works of contraction stimulation; and stimulation diffusion through transverse tubules, calcium release, and stimulation of contraction components that are responsible for generation of strength and power [12]. While general fatigue is defined as a reduction in the ability to produce the desired power arising from discontinuation of the chain of events from the central nervous system to muscle fibers [11].

In other words, the general fatigue relates to events of neuronal inputs to the upper parts of the brain and the call for alpha motor neurons. It may relate to the whole body and in particular the central nervous system [11, 14]. Most studies on fatigue investigate muscle fatigue or certain group of muscles in pure form and examined it with isometric, concentric or eccentric contraction. However, the main activities of human muscles, especially those involved in motion and sport activities, are expressed in the form of repeated muscle Stretch-Shortening Cycles (SSC) [15]. This kind of contraction is one of the suitable methods to induce functional fatigue.

Running, walking, and jumping are examples of performing SSC [16] Several epidemiological studies reported that the most common time of occurrence of injury is at the conclusion of activity when the person develops fatigue [17-19]. Hawkins reported that 58% of injuries are of non-contact type [18]. Arcelin showed that the reaction time at the end of long duration activities, when the person is fatigued, also becomes longer [20]. This evidence proves the impact of fatigue on injury that acts through altering the sensory-motion system [8, 10, 21] and information processing system [6].

On the other hand, it has been reported that muscular tiredness and muscles' tolerance capacity are different in men and women due to the difference in muscular mass, muscle morphology and substrate utilization [22]. Therefore, different characteristics of fatigue between men and women might have different impacts on their choice reaction time which may contribute to more injury in women [23-25]. In this regard, to prevent injury and better rehabilitation, men and women should be treated with different treatment programs for achieving a desirable outcome. Accordingly, the present study aimed to examine the effect of functional fatigue on choice reaction time in men and women.

2. Materials and Methods

The present study was conducted in the summer of 2014 at the biomechanics laboratory of the Research Center of the Faculty of Rehabilitation Sciences of Iran University of Medical Sciences and Treatment Services. This study has quasi-experimental design with the pretest and posttest. In this study, 16 healthy women and 16 healthy men with an age range of 18 to 35 years participated. They were selected through simple non-probability sampling method from the Faculty of Rehabilitation Sciences of Iran University and the University of Social Welfare and Rehabilitation Sciences.The exclusion criteria included history of lasting injury or illness in the lower limbs or spine, history of cardiorespiratory and neurological illnesses, lower limbs surgery, and real length difference of more than 1 cm in the lower limbs, as well as significant congenital malformations of the lower limbs, excessive obesity (body mass index more than 30), and lower limbs pain during execution of the test. Then, they were briefed regarding the test procedure. When they accepted to participate, they signed their written consent forms.

At first, all details of the study procedure were explained to the participants. To prevent the occurrence of injury, prior to the test, the participants exercised with the fixed bicycle for 5 minutes to warm up and performed stretching exercises special to hamstring, quadriceps and cuff muscles. Then, the test of 4-choice reaction time was conducted before the fatigue. Then the fatigue protocol was performed and finally the test was taken again.

Fatigue protocol

This protocol included consecutive jumps on the tatami mattress. The speed of the participant's jump was adjusted based on the metronome sound equal to 108 beep sound per minute [14]. By each beep sound, the participant would bring down one foot on the mattress. In case the participant would bring down his or her foot with a speed other than the metronome speed, or in case the participant was not able to continue the jump, he or she would have 30 seconds of active rest in the form of walking. These steps were repeated 5 times [14].

For measuring the fatigue level, the Borg Scale was used. At conclusion of the last step, the participant would express his or her real feeling in view of intensity of the activity he or she has carried out and its scale was extracted by using the table designed by Borg. The participant should select the minimum scale equivalent to hard activity (number 15) so that his or her fatigue could be confirmed.

The choice action test

The reaction time was checked by DLRT software. To determine the choice reaction time, we used the visual stimulus, which was introduced at random time. In this test, there were four white squares. By the appearance of a cross in each of the squares, the participant should immediately press the button related to that square. For each particular stimulus, pressing a special button on the keyboard was considered as response. The stimuli were repeated 30 times. Duration of the test for reaction time in the choice mode before and after fatigue was two minutes. Reaction time was calculated by the software in terms of milliseconds.

Statistical methods

In the present research, the descriptive statistics was used for data classification and inferential statistics for data analysis. For comparing the reaction time before and after fatigue between two groups, the correlated t test (intra-group comparison) and for examining the impact of fatigue on choice reaction time and examining the intergroup differences, the covariance analysis test was used.

Statistical analysis was performed by SPSS 19. The significant level was considered at 0.05. Presuppositions for covariance analysis test were as follows: normal distribution of scores, linearity of the relation between pretest and posttest, homogeneity of groups' variances, and equality of regression coefficients in the pretest. In the present study, all these presuppositions were established by using the Kolmogorov-Smirnov, Levene's test and variance analysis.

3. Results

Descriptive statistics of the participants and their reaction time are presented in Tables 1 and 2, respectively. To compare the choice reaction time before and after fatigue between two groups of men and women, the t test was used. For examining the effect of fatigue on choice reaction time and the difference between the two groups in the posttest, the covariance analysis test was used by considering the pretest effect as control, the results of which are shown in Tables 2 and 3, respectively.

The results of the correlated t test (intra-group comparison) in Table 2 indicate that the difference in choice reaction time after the fatigue protocol as compared with rest mode was not significant. In other words, fatigue did not have a considerable effect on the choice reaction time of the participants. According to Table 3, the results of

Table 1. The participants' demographic characteristics

Statistical Indicators	Group	Mean (SD)	Significant Level of K-S Test
Age, y	Men	28.40(4.42)	*0.46
	Women	28.10(5.82)	
Weight, kg	Men	74.31(12.76)	0.001
	Women	58.15(8.97)	
Height, cm	Men	176.90(6.93)	0.000
	Women	165.20(4.44)	
Time reaching fatigue (in minutes)	Men	2.72(1.66)	*0.22
	Women	1.82(1.32)	

*Indicates normal distribution of data.

Table 2. Descriptive statistics of reaction time and results of correlated t test

Variable	Group		Mean (SD)	T	Significant Level
Choice reaction time	Men	Before fatigue	854.53(69.94)	-0.54	0.59
		After fatigue	864.11(77.19)		
	Women	Before fatigue	856.39(61.87)	-0.36	0.71
		After fatigue	860.20(75.88)		

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Table 3. Results of the two groups' covariance analysis in the choice reaction time

Indicator	Total Sum of Squares	df	Mean Squares	F-Coefficient	Significant Level
Group's pretest choice reaction time	77300.305	1	77300.305	19.767	0.000
	3293.547	1	3293.547	0.842	0.366

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covariance analysis indicate that the F value of the independent variable (group) is not significant. There is no significant difference between male and female choice reaction time after eliminating the effect of pretest.

4. Discussion

In this study no difference was observed in the choice reaction time between men and women. In this regard, this study result was consistent with studies conducted by Nasiri, Abdi, and Dykiert who stated that adult men and women act equally with respect to the choice reaction time [26-28]. However, this finding was not in line with findings of a number of studies that show a better choice reaction time in women as compared with men [29-32]. The reason for contradiction of these findings can be the nature and complexity of cognitive tasks that require more central processing. In his study, Adam also saw the greatest difference in the choice reaction time between men and women in tests with more choices in conditions of incompatibility between the stimulus and the response [31]. Results of these studies demonstrate that different strategies are employed by men and women to process the information, and the better performance of men as compared with women in such tasks.

Contrary to the studies that supported the impact of fatigue on prolonging the reaction time [33-35], in the present study, fatigue lacked a considerable effect on the participant's choice reaction time. Although, after fatigue, the mean score for reaction time increased in men and women, this difference was not significant. These findings were consistent with findings of Bender, Yeung, and Ozdemir [36-38]. Reaction time comprised two parts of motor time and premotor time [2]. It is possible that with fatigue and prolongation of motor time, the premotor time becomes quicker and makes up for the prolonged motor time, which leads to no significant change being observed in the overall reaction time [36].

Various studies have shown that the level of contribution of peripheral and central fatigue depends on the type and intensity of activity [8, 33, 39, 40]. Lepers in his study examined neuromuscular activity during cycling exercise with below-maximum intensity for a lengthy period of 5 hours [8]. Results of the study showed that at the beginning of activity (after one hour) a significant difference was seen in contraction characteristics, while disorder in stimulability and central drive occurred in later hours. In other words, the central portion of muscle fatigue has helped further decrease the maximum volitional force at the end of exercise.

Based on the study results, in activities with the intensity below the maximum, the peripheral fatigue occurs sooner than the central fatigue. Also the reduction of muscle power at the beginning of activity is due to peripheral fatigue that occurs at the muscle's nerve commissure or inside muscle's cell. After that, the central fatigue occurs in a way that the number of recruitment of new motor units or the frequency of employing active motor units decreases and helps further reduce muscle strength. Unlike these studies that used electromyography to determine fatigue, we used the Borg scale which is a quality tool to measure the intensity of fatigue.

It seems that the participants in this study have become fatigued with lower intensity and their fatigue was the result of peripheral fatigue [36]. In other words, before occurring the central fatigue, the participants have stopped their activities. Thus, low level of fatigue (lower reduction of power) has not caused a disruption in the central nervous system and information processing. Therefore, this factor has made insignificant the effect of fatigue on choice reaction time.

Also, despite different characteristics of fatigue in men and women, no difference was observed between the choice reaction time of two genders. This finding is in line with findings of Hicks who indicated that gender differences disappear when the fatigue protocol was performed with lower intensities [22]. However, for more accurate study of fatigue and its effects on two genders, we suggest that in future studies more accurate tools such as electromyography be used to determine fatigue or the activity intensity (VO_2 max, HR max or MVC%) in the fatigue protocol.

Fatigue has no considerable impact on the choice reaction time of healthy non-athlete men and women. And despite different fatigue characteristics in men and women, no difference was observed between men and women with respect to the choice reaction time.

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Conflict of Interest

The authors declared no conflicts of interest.

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