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The effect of acute vibration on visual reaction time in fencers

El efecto de la vibración aguda en el tiempo de reacción visual en esgrimidor

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Resumen

El propósito de este estudio es determinar el efecto de un ejercicio de vibración local aguda en el tiempo de reacción visual de las extremidades superiores de un esgrimidor. Veintiséis esgrimidores masculinos entre las edades de 15 y 23 (edad media, 17.38 ± 2.13 años, altura: 173.6 ± 9.1 cm, masa corporal: 70.2 ± 14.1 kg) se ofrecieron como voluntarios para este estudio. La prueba del tiempo de reacción se aplicó antes y después del ejercicio de vibración (aplicado durante 30 segundos en 27 Hz con una amplitud de 2 mm). Después de 25 min. calentamiento estándar, se informó a los esgrimidores sobre la prueba y se realizaron tres pruebas de reacción repetidas para proporcionar familiarización. Los esgrimidores comenzaron la prueba de reacción en la posición estándar de protección de esgrima. De acuerdo con cinco señales que vienen a intervalos de dos a cinco segundos desde el monitor objetivo, los esgrimistas hicieron un toque al doblarse (atacar). La prueba del tiempo de reacción tuvo cinco ensayos. Se compararon los valores promedio de tiempo de reacción pre-vibración y post-vibración. El tiempo de reacción visual medido antes de la vibración fue significativamente mayor que el medido después de la vibración (p <0.001). El ejercicio de vibración local aguda aplicado a los esgrimidores acortó el tiempo de reacción visual. Dado que la vibración puede mejorar la RT, el uso de la vibración en el entrenamiento tiene el potencial de proporcionar una ventaja a los esgrimidores.

Palabras clave

Esgrima; vibración; tiempo de reacción.

Abstract

The purpose of this study is to determine the effect of an acute local vibration exercise on the visual reaction time of a fencer's upper body extremities. Twenty-six male fencers between the ages of 15 and 23 (mean age, 17.38 ± 2.13 years, height: 173.6±9.1 cm, body mass: 70.2 ±14.1 kg) volunteered for this study. The reaction time test was applied before and after the vibration exercise (applied for 30 seconds in 27 Hz with a 2-mm amplitude). After 25 min. standard warming up, fencers were informed about the test, and three repeated reaction tests were performed to provide familiarization. The fencers started the reaction test in the standard fencing guard position. According to five signals coming at two to five second intervals from the target monitor, the fencers made touché by bending (attacking). The reaction time test had five trials. The average reaction time values pre-vibration, and post-vibration were compared. The visual reaction time measured pre-vibration were significantly longer than those measured post-vibration (p<0.001). Acute local vibration exercise applied to fencers shortened the visual reaction time. Given the fact that vibration can improve RT, the use of vibration in training has the potential to provide an advantage to fencers.

Keywords

Fencing; vibration; reaction time.

Introduction

Fencing is a combat sport containing explosive attacks and muscle coordination (Balkó Š, Borysiuk & Šimonek 2016). Fencers must have the ability to make quick decisions and have quicker reaction time (RT) abilities to implement this decision. Many researchers emphasized the importance of RT to succeed in three branches of fencing and also another branch such as karate and boxing (Balkó Š, Rous, Balkó, I, Hnízdil & Borysiuk, 2017; Moscatelli et al. 2016). It is a complicated and lengthy process to improve the RT and apply this improvement within the technical skill. RT can be improved up to 10-15% of its initial level at most (Balkó et al., 2017). Consequently, any method that can provide an improvement RT should not be ignored.

Effect of vibration on athletic performance has become an important research topic in recent years (Muniz-Pardos, 2020; Gürol, Güven & Güngör, 2019; Souron et al., 2019). Many studies have found that vibration has a positive effect on neuromuscular performance (Issurin, 2005; Mileva, Naleem, Biswas, Marwood & Bowtell 2006; Annino et al., 2017). Cochrane (2016) found that apply direct vibration on biceps brachii in master athletes cause an increase in peak power and mean concentric power. The effects of vibration on the muscle are shown by electromyography and spinal excitability, and neural effect was also mentioned (Smith & Brouwer, 2005). Wallman et al. (2019) reported that whole body vibration (WBV) has not significantly affect vertical jump performance on male subjects, but it caused a decrease in female subjects. In, the same study, researchers found that WBV has a positive effect on improving agility and some components of dynamic balance. There is very little published research on the effect of vibration on RT (Newell & Mansfield, 2008; Sabzi A. H., Abbasi, A., Rostamkhany H. & Sabzi E., 2012), and the methods of these studies were not similar to our research's method.

Attention has an important role for RT, and it is the primary input processing mechanism (Gutierrez-Davila, Rojas, Gutierrez-Cruz & Navarro, 2017). It is possible to develop these processes with specific training. Increased spinal excitability with increased neuromuscular performance may also affect RT.

Researchers have mainly focused on WBV studies (Cardinale & Wakeling, 2005; Delecluse, Roelants & Verschueren, 2003; Fowler, Palumbo, Feland & Blotter, 2019) and selected large muscle groups in their investigations (Pujari, Neilson & Cardinale, 2019; Rehn, Lidström J, Skoglund & Lindström B, 2007). However, this study was designed to investigate the effect of local vibration because the upper extremity was the critical predictor to get the point in fencing. The aim of this study was to investigate the effect of acute local vibration on visual RT in male fencers.

Methods

The participants were informed about the test, and three repeated reaction tests were performed to provide familiarization. They were asked to 25-minute warm-up according to their own needs after familiarization. After the warm-up period, the reaction test was applied to the participants. The test had five trials, and the results of these five trials were averaged. The response time between the target stimulus (i.e., red light) and hit the screen (*touche*) were measured for all trials. All participants performed a simple attack (direct touche). Regarding the direct *touche* from the *en garde* position, the participant had to hit the target with only an arm movement. After recording the RT, 30 seconds vibration was applied to the dominant upper extremity in biceps curl position similar *en garde* position. Immediately after the vibration application, five repeated reaction tests were applied again, and results were averaged. All of the measurements were completed between 09:00 am - 11:00 am in two days.

Twenty-six male fencers who were participating in the (seven cadets, fifteen juniors, and four seniors) National Fencing Federation between 2012 and 2013 volunteered for the study (mean age, 17.3±2.1 years; mean height, 173.6±9.1 cm; mean weight, 70.2±14.1 kg). All of the fencers had more than four years of fencing experience. The research protocol was approved by the Local Ethics Board for Non-Interventional Studies (Decision number: 2012/37-03) and informed consent was obtained from the adults and legal representatives of participants under the age of 18 that they were volunteers.

Reaction time measurement: RT was measured by a custom device developed by researchers. Reaction Time V4 software was used for designing this device. The measurement device uses an ATMega328 processor that runs at 16 MHz. The device works industrial microprocessors, like stopwatch systems. The internal clocks of the processors operate with microseconds precision. In this type of industrial system, the sensitivity of the components is shown in the data schemes after production ("ATmega328p Datasheet, 2020"). It was designed in a way similar to the systems used in fencing. It acquires a signal when the tip of the weapon touches the screen and transmits it to the computer. Data below 100 ms and above 700 ms were not taken into account.

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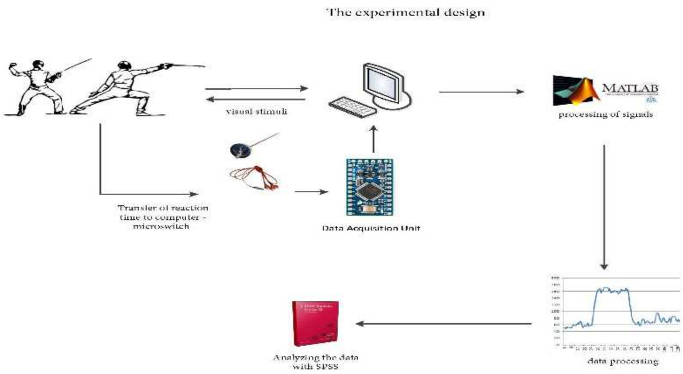

Figure 1: Experimental Design of Reaction Time

***Computer software settings*:** The duration of the standby time for five trials, was adjusted between two to five seconds. Thus, the test was completed within 10-25 seconds. The visual signals produced by the computer software were sent to the monitor that was used as the target. The signal was a red symbol on a white background on the computer screen. The height of the monitor screen was 47 cm, and the width was 27 cm. The monitor screen was strengthened with a 5-mm-thick piece of plexiglass, the same size as the screen. The height of the target was 140 cm. Fencers have started the measure in the *en garde* position. The height of the target was determined to be suitable to en garde position of the fencers. The target monitor was placed 25 cm from the point of the fencer's weapon.

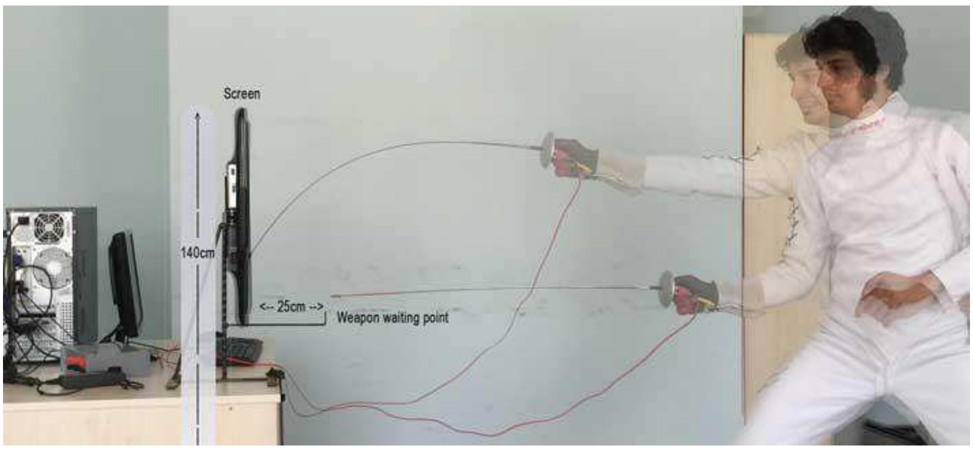

Figure 2: Reaction Time Measurement Device and Position

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Application of vibration: While fencers were standing, vibration (27 Hz, 2 mm) was applied 30s to the dominant arm with a vibration dumbbell (Mini-VibraFlex Plus®, Orthometrix, Inc., White Plains, USA). The arm was kept in the biceps curl position during the application of vibration to be similar to the en garde position in the fencing. A vibration device with a frequency range of 5 to 40 Hz, an amplitude of 2 mm, a maximum acceleration of 12.9 g, a weight of dumbbell 2.6 kg, overall dimensions of dumbbell (l/w/h) 280 x 200 x 60 mm and a control unit was used.

Data analyses: Basic descriptive analyzes were performed where the results were expressed by the mean and standard or standard deviation for the quantitative variables. A Boxplot test was performed to test whether there is any outlier data. The normality of the variables was studied using the Shapiro-Wilk test. Then Paired Samples T-Test was applied.

A Spearman's rank-order correlation was run to assess the relationship between reaction time and anthropometric measures.

The value of p was adjusted to $p < 0.05$. All analyzes were performed using the IBM SPSS Statistics 20.

Findings

Descriptive data on the body composition of the fencers were presented as means and standard deviations in Table 1.

Table 1. Anthropometrical Characteristics of Fencers

	Mean ± SD (n:26)
Age (year)	17.3±2.1
Weight (kg)	70.2±14.1
Height (cm)	173.6±9.1
Body mass index (kg/m²)	22.8±4.0
Fat percentage (%)	13.3±5.4

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A paired-samples t-test was used to determine whether there was a statistically significant mean difference between the reaction time when participants post vibration applying compared to a pre vibration. Data are mean ± standard deviation, unless otherwise stated. Two outliers were detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. Inspection of their values did not reveal them to be extreme and they were kept in the analysis. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (p = .088). Participants reacted faster on post vibration test (396,95 ± 49,64 ms) as opposed to the pre vibration test (417,30 ± 52,29 ms), a statistically significant decrease of 21,36 (95%CI, 34,60 to 8,11 ms, $t(25)$ = 3.321, $p < .005$, d = .651. Table 2 displays the experimental data on RT.

Table 2: Reaction Times of Pre and Post Vibration

Reaction Time Test	Mean (ms) ± SD n:26	p
Pre Vibration	417,30± 52,29	
Post Vibration	**395,95± 49,64***	**.003**

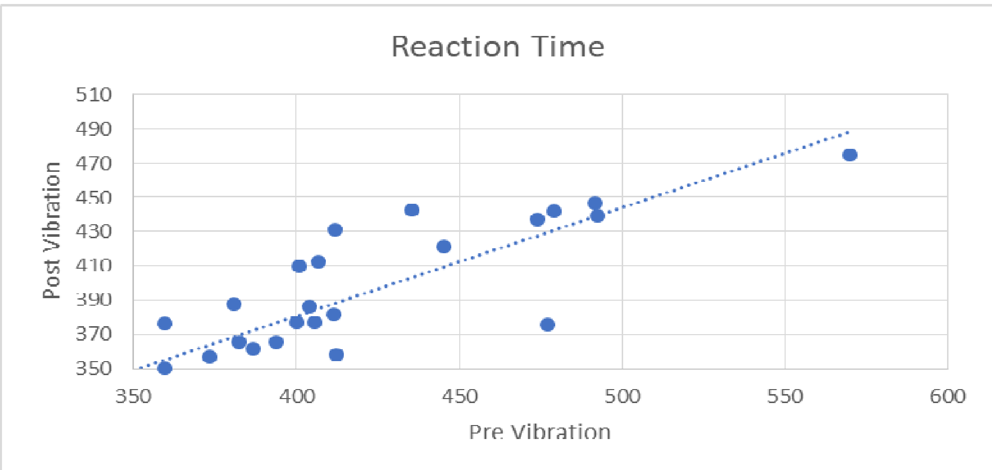

Figure 3: Distribution of Reaction Time

A Spearman's rank-order correlation was run to assess the relationship only between reaction time and age. Twenty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant, moderate negative correlation between age and reaction time, r_s (24) = .56, $p < .005$.

Discussion

To our knowledge this is the first study to investigate the effect of acute local vibration on upper limb RT in fencers. We found that acute local vibration improves the visual RT for the simple attack, which is one of the attack movements that used to get the point in fencing. The second finding is that there is a negative relationship between reaction time and age.

Literature reviews have indicated that there were another studies that found positive effects of acute vibration on physical performance parameters (Tok, Fowler, Çolakoğlu M, Bademkıran and Çolakoğlu Z, 2010; Annino et al., 2017). For example, Atış, Gelen and Yıldız (2018), concluded that applying WBV to karate athletes between the range of 25-35 Hz lead to better results in sit and reach flexibility test and 30 and 35 Hz lead to better results in jumping performance. These frequencies are consistent with our vibration frequency so to reveal the positive effects of vibration application 25-35 Hz may be sufficient. It should not be forgotten that the participants are regularly trained athletes in both studies. The same vibration frequencies may lead to different results in untrained or recreationally trained participants (Ronnestad, 2009).

In contrast, in another study authors applied local vibration to physically active males and they did not find any differences in isometric, dynamic muscle performance, and jumping performances (Souron et al., 2019). Also some studies in the literature support this finding (Humphries, Warman, Purton, Doyle and Dugan 2004; De Ruiter, Van Der Linden, Van Der Zijden, Hollander & De Hann, 2003). These conflicting findings may be explained by several different factors like the contraction velocity of the applied exercise (Humphries et al., 2004), different modes of vibration, sets of vibration, or exercise background of the subjects. In the current study, RT was tested by applying a technique and motion pattern that our participants were experienced before. In this way, our participants may have better adapted to the test and the responses to vibration may have appeared more quickly.

Gürol et al. (2019) reported that 25 Hz and 50 Hz WBV application caused a statistically significant high jumps heights in male participants. Moreover this increase continued 15 minutes later than the vibration application. Similar to the current study, Chang, Hung, Ho and Lin (2019) aimed to investigate the acute effects of WBV on male fencers' performance. They found statistically better results in lunge reaction test and countermovement jump test 1 and 2 minutes later the WBV intervention compared to preintervention. Although we only investigated the reaction time of the upper limb, lower limb power is crucial in a fencing bout. When these findings evaluated together, it shows that applying acute vibration sessions before the bout may help improve upper and lower body performance. Although a fencing bout lasts of 3 minutes, considering the prolonged bout, preparations before the bout, more information on the duration of positive effects of vibration would help to establish a greater degree of accuracy on this matter.

Martínez de Quel, Saucedo, López & Sillero, (2008) used the program SuperLab Pro 2.0 (Cedrus, San Pedro, ('A, USA) and found that the RT of Spanish male fencers was 356.49±38.50 ms. Harmenberg, Ceci, Barvestad, Hjerpe and Nystörm (1991) reported that the mean RTs of Swedish male fencers were 391.00±0.04 ms, 277.00±0.09 ms and 333.00±0.10 ms using three different types of tests which was similar to the method published by Singer (1968). Although the method of this study is similar to the current study, their subjects used a fencing lunge and fleche against the target but the subjects in the current study performed a simple attack (only an arm movement). The difference between the two results may be due to the method's diversity. Delignières, Brisswalter and Legros (1994) reported RT of 270.35±25.49 ms. RT tasks in their study was performed on a computer, connected to two joysticks, held in front of the ergometer handlebar. In the present study, there was an area of 25 cm between target monitor and the point of the fencer's weapon yet Delignières et al. used joystick like a simple button reaction test. This situation may cause a quicker RT compared to the present study. In a study of elite and beginner fencer's simple RTs were compared, the results were 262.5 ms for elite fencers and 292 ms for beginner fencers. For the simple RT test, subjects had to start on guard position and perform an extension in the elbow joint for hitting the target. The target was placed 125 cm from the horizontal obstacle (Balkó et al., 2016). Even though methods seems similar, considering that fencing weapon length is 110 cm, Balkó et al. had a closer distance between the target and point of the weapon compared to the present study. Also the present study had younger fencers. Considering these differences RT results in this study seems acceptable. Additionally better RT results for senior fencers supported by the negative relationship between reaction time and age that we found in the present study.

Cardinale and Wakeling (2005), reported that acute WBV at a low frequency (20 Hz) enhanced neuro-muscular performance in individuals who did not do exercise. WBV can cause an effect similar to observed in resistance and explosive strength training by creating a neural potentiation effect (Delecluse et al., 2003). It has to be similar for local vibration. Vibratory stimulus results in reflexive muscle contractions by activating the sensory receptors (Delecluse et al., 2003). The reflex activation of the alpha motor neuron during vibration application has also known by the authors (Cardinale & Bosco, 2003; Nishihira et al., 2002). The increase of sensitivity of the stretch reflex after vibration probably causes the improvement of neuromuscular performance. Besides, vibration application can cause vary the intramuscular coordination patterns by inhibiting the activation of antagonist's muscles through Ia- inhibitory neurons (Cardinale & Bosco, 2003). At the same time literature showed that vibration can cause a post activation potentiation effect (Cochrane, Stannard, Firth & Rittweger, 2010). These findings suggest that in general neuromuscular activation is positively affected by vibration application and this case can improve reaction time.

Besides the acute effects of vibration, there were also studies in literatüre that deal with the chronic effects of vibration (Verschueren et al., 2004; Centner, Ritzmann, Gollhofer & König, 2020). Sabzi AH et al. (2012) reported that a twelve-week (three days/week) WBV application, cause a statistically significant improvement in the RT when compared with the control group. In fencing to find the optimal time for response to the rival’s movements is the main factor. One of the most important measurable indicators of this response is RT. Therefore a future study investigating the chronic effects of vibration on RT in fencers would be valuable.

Conclusion

In conclusion, acute local vibration caused a significant improvement in the visual RT of fencers. Given the fact that vibration can improve RT, the use of vibration in training has the potential to provide an advantage to fencers. Thus, fencers and coaches should consider using vibration training to support their traditional training methods. Furthermore, it can also be useful to incorporate vibration exercise into the warm-up routine before competition or training. Additional studies are required to understand the effect of vibration on the human body.

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Supplementary Content