Evaluation of the time for the electromyographic response in volleyball athletes and non-athletes who had ankle sprain

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ABSTRACT

The purpose of this study was to examine the time for the electromyographic response of the fibular muscles in the sudden foot inversion in sprained and healthy ankles. Three groups of athletes were tested: one composed by healthy athletes (group 1), one group of athletes with recent history of ankle sprain (group 2), and another group composed by non-athletes with recent history of ankle sprain (group 3). For each individual from the three groups both ankles were tested. Individuals with ankle sprain (groups 2 and 3) were asymptomatic for the last two months prior to the test. A platform able to produce a sudden 20º side inversion of the ankle in the frontal plane simulated an ankle sprain event. Surface electromyography electrodes were placed over the fibular muscles. Times for the electromyographic response of the fibular muscles were obtained and compared between groups. In group 1, the mean electromyographic response times were: 71 ms for the right leg, and 69 ms for the left leg. In group 2, the mean electromyographic response times were: 72 ms for non-sprained ankle, and 74 ms for sprained ankle. In group 3, the mean electromyographic response times were: 72 ms for non-sprained ankle and 73 ms for sprained ankle. Results indicated no statistically significant difference between the right and left legs in group 1, and between non-sprained and sprained ankle in groups 2 and 3 for the fibular muscles. The findings in the present study suggest that the time for the electromyographic response of the fibular muscles to sudden angular displacement of the ankle was not influenced by the ankle sprain.

Keywords: Time for the electromyographic response. Sprain. Ankle.

INTRODUCTION

The sprain is considered the most common occurrence in the ankle articulation[1]. The high incidence of this type of injury occurs while practicing both contact[2,3] and non-contact sports such as volleyball[1,4-6]. This fact is mainly due to the sportive gesture performed while practicing these sports, and the jumps, runs and ground falls after a jump are the main responsible causes for the ankle sprains (21 to 25%)[3,7]. Sprains account for 75% of these injuries, while the mechanism by inversion reaches 85 or 90%[3,5,8]. Such injury is characterized by: the tensing up and/or the complete or incomplete rupture of the ligaments of the 2 and 3 grades, respectively, capsular loosening, and muscular instability[9-12]. The "deformations" produced by an excessive tensing up of the tissues occur in the side portion of the leg, mainly reaching the short and long fibular muscles. With such tensing up, it can occur situations such as changes in the proprioceptive ability caused by the injury and the articular instability[13-16].

The sprains can be classified according to the intensity of the trauma: a) *Grade I or mild* – the integrity of almost every ligamentous fibers is kept. There is a small vasomotor reaction generally characterized by an edema. During the acute phase, there is a mild pain. There is a ready reestablishment of the support and march; b) *Grade II or moderate* – there is hematoma and a larger dimension edema due to a wider vascular injury. Through the prior drawer test, it is noted a small instability whenever the stressed articulation is submitted to the examination. There is a higher algetic and inflammatory picture than grade I, and consequently, the support and march are difficult, only returning after the regression of the symptoms. At such grade, it appears a partial rupture of the ligaments; c) *Grade III or severe* – there is intense pain, a wide area with rupture of vases showing an important edema, a widely extent hematoma, and a tumefaction in the ankle articulation. It appears a radiological instability by a large aperture stress, and it may have bone avulsions. Also, upon the prior drawer test, it is possible to verify a great instability.

There is a complete rupture of the capsule-ligamentous structures, and this is proved through the arthrography, due to the extravasation of liquids in regions where they normally are not supposed to be found. In such a grade, generally it is required a surgical treatment[9,12].

One of the ways to detect the reduction in the proprioceptive capability due to the ankle sprain is determining the time for the electromyographic response of the everter muscles of the foot through the surface electromyography[17-21]. So, the time for the electromyographic response is defined as the value of the difference which can be obtained between the muscle stimulus, and this can be supplied through a sudden movement to activate the distension of the muscles up to the reaction of the muscle to the stimulus. In the ankle sprain by inversion, it must be activated the everter muscles of the side portion of the leg simulating a sprain mechanism. Such electromyographic response is measured in milliseconds, and it can be obtained by the surface electromyography.

In such a sense, it was presented evidences in studies evaluating the postural response on healthy individuals and patients with recent history of ankle sprain from changes in a supporting surface of the feet created during a frontal plane swinging. Results

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confirmed that the reduction in the proprioceptive capability after a sprain that affected the ankle articulation resulted in a delay in the time for the electromyographic response of the fibular long and anterior tibialis muscles recorded by the electromyography[13]. Nevertheless, this idea has been debated by other authors who did not find any changes in the electromyographic response time of the everter muscles of the feet among healthy individuals, and individuals with a history of ankle sprain[8,20,22].

Having in mind the increasing number of volleyball players both in Brazil and around the world, as well as the high incidence of ankle sprain occurred in such sports[1,4,6,23], the solution for controversies related to the use of the electromyographic response time as a way to investigate the reduction in the proprioceptive capability in athletes, it would be very helpful for physicians and physiotherapists to determine the moment when an athlete can return to his regular training activities. Nevertheless, it was found in the literature no systematic study evaluating the electrical response of the muscles in healthy volleyball athletes with recent history of ankle sprain.

Therefore, based on the investigation as to the existence or not of a delay in the time for the electromyographic response using a 20º falling platform simulating the inversion movements of the ankle articulation, as well as the surface electromyography to record the electrical activity of the muscles, the purpose of this study was to compare the times for the electromyographic response in the everter (short and long fibular) muscles from the athletes' foot with healthy ankles, and athletes and non-athletes with recent history of inversion sprain of the ankle.

MATERIAL AND METHODS

The sampling was constituted by sixteen 14 to 25 years old professional volleyball players (mean 17.5 years; standard deviation 2.12, and mode = 16), and fifteen 19 to 40 years old non-athlete individuals of both genders (mean 25.06 years; standard deviation 5.82, and mode = 22). The sampling used in this study was intentional. Three groups were formed to the data collection. Group 1 (controlling group) was composed by athletes practicing volleyball for the last three years, with a five days per week and three hours per day training frequency, who were considered professional players, and presenting healthy ankles.

Group 2 was also composed by volleyball players with the same characteristics found in group 1, but presenting a recent history of unilateral grade II ankle sprain[9-12] by foot inversion. Group 3 was composed by non-athlete individuals also with a recent history of grade II ankle sprain by inversion[9-12].

Individuals who had ankle sprain (groups 2 and 3) were asymptomatic as to the injury for the last two months prior to the test. Therefore, the inclusion criteria to the study were: volleyball athletes with three years practice in the modality, with grade II ankle sprain[9,12], and others presenting non-sprained ankles, and non-sprained ankles and non-athlete individuals with healthy ankles. The exclusion criteria included volleyball athletes who practiced the modality for less than three years, presenting injuries in the hips and knees or other diagnosed injury than second grade sprain. It was also excluded from the study non-athletes injured in the hips and knees or who had other diagnosis than second grade sprained ankle.

Data collection procedure

It was used as recent history of ankle sprain the period comprised between the fourth and tenth weeks after the injury, when every individual of the study was analyzed. Group 2 individuals were evaluated by the mean sprain time of 6.8 weeks (standard deviation, 2.70), and group 3 by mean sprain time of 5.8 weeks (standard deviation, 2.20). That period was related to the fact that the collagen fibers would already support almost normal loads, and that is the phase in which individuals are released to return to their sportive practice[24,25].

In order to make the diagnosis of the second grade ankle sprain, it was performed a physical examination through the previously mentioned drawer test, always performed by the same Traumatologist, and using the classification according to the intensity of the trauma presented in the literature as grade I or mild, grade II or moderate, and grade III or severe[9-12].

From that diagnosis, athletes and patients were treated with the *Air Cast* immobilizer which was performed by the same Traumatologist, and they were guided to the physiotherapeutic treatment. Whenever they were nearby the end of the fourth week of the treatment, they were guided to the Exercise Laboratory (LAPEX) of the Rio Grande do Sul Federal University (UFRGS) to start the data collection. At that moment, all individuals presented no pain signal or instability complaints.

An eight channel electromyography (*Bortec Electronics Incorporation*, Canada) was used to acquire the electromyographic signals (EMG). Surface disposable adhesive electrodes in bipolar configuration (1 centimeter diameter each) were placed on the fibular muscles of the abdomen (right and left leg) towards their longitudinal axle (1/3 below the fibula's head). The distance between electrodes was approximately of three centimeters. An adhesive and disposable grounding electrode was placed on the anterior tuberosity of the tibia (left), parallel to the position of the electrodes in the fibular muscles. The skin under the electrodes was shaved using a disposable razor, and it suffered abrasion with a cotton soaked in alcohol to remove dead cells in order to reduce the electrical impedance and oily from the spot where the electrodes would be placed[26], to prepared it to catch the electromyographic signals. Next, electrodes were fixed on the skin, and a mild pressure was applied on the electrodes to increase the contact between the electrode's gel and the skin[27]. The impedance between electrodes was measured through a voltmeter, and it was kept below 5 KOhms. Both legs were prepared in the same way, once the one presenting the healthy ankle was considered the control one. The electromyographic signals were caught along with the platform signal (synchronism). These signals were sampled at a 4,000 Hz frequency. The electromyographic signal was filtered with the optimum filter with 20 Hz minimum frequency, and 700 Hz maximum.

The Laboratory of Mechanical Measurements from the UFRGS in Porto Alegre/RS School of Engineering developed an inversion platform, whose board allowed a foot inversion (at the frontal plane), simulating a 20º subtalar inversion movement. Such platform was similar to the one used by Karlsson *et al.* (1992)[19]. A manual synchronism system was installed in order to generate an electrical signal that would indicate the beginning of the inversion movement in the ankle. This was an individual system for each of the sides of the platform, and it was used to synchronize the inversion events in the ankle with the electrical activation of the muscle. The signal was activated by the researcher by means of independently pulled strings for each of the platform's sides (figure 1). When one of the sides of the platform would fall when the rope was pulled, the synchronism was turned off, thus generating a signal on the computer's monitor together with the electrical signal of the muscle that came from the electromyography. The difference between both signals corresponded to the time for the electromyographic response of the muscle studied.

The position of the individuals on the platform adopted a standard procedure (figure 2), where they remained with their eyes closed or open, performing a protocol consisted in twelve inversion movements randomly produced in both ankles, being inversions with individuals keeping their eyes open, and six inversions with their eyes closed, according to the randomized protocol. It was used three movements for each side, with the purpose to avoid a possible training to the task.

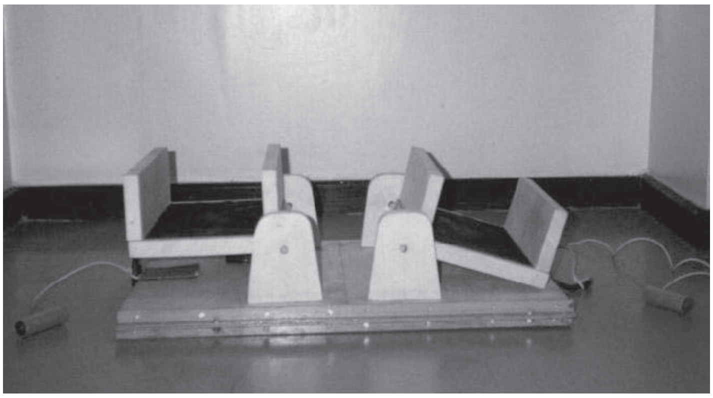

Fig. 1 – *Inversion platform: showing the 20º angular displacement on the right side of the board to which individuals were submitted during the experiment. The left side of the board shows the position where the left ankle of the individual remained while the displacement of the right side occurred.*

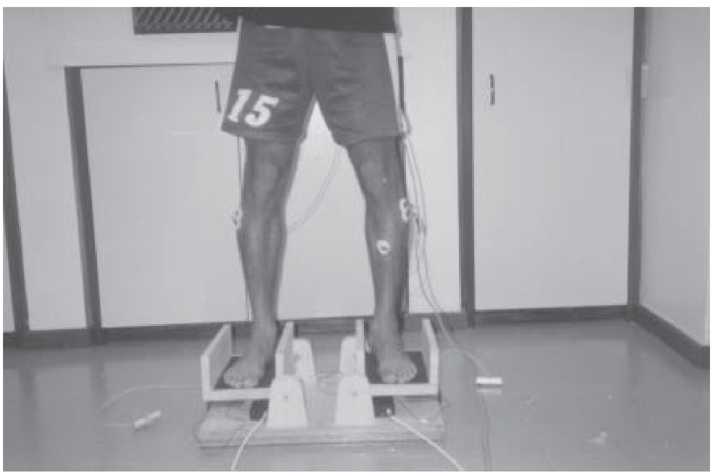

Fig. 2 – *Anterior view of the individual on the platform*

An extra care was adopted so that every inversion was sudden and unexpected. To use such surprise factor, mechanisms such as conversations between the researcher and the research assistant were adopted, for the individual to be distracted and he would not be aware of when and which side the inversion movement of the ankle would happen. No signal of pain was mentioned by individuals during the tests. The electromyographic signals were caught along with the platform signal (synchronism).

Every procedure in this study was approved by the Human Research Ethics Committee from Hospital de Clínicas de Porto Alegre/RS in March 28, 2001 under the number 01-074, and approved through an informed consent for each individual.

Statistical analysis

The paired *t* test was used in each group, in order to compare the times for the electromyographic response between individuals with eyes open and closed for the right and left ankles, and making a comparison between the right and left ankles (group 1), and between non-sprained and sprained ankles (groups 2 and 3) as to the times for the electromyographic response.

The significance level used was $p < 0.05$ for every analysis.

RESULTS

The below graphics present as subtitle for group 1, right and left ankles, since it comprises the analysis of a non-injured group, and therefore having healthy ankles. For groups 2 and 3, it was used as subtitle the terms non-injured and injured, since they are groups of individuals with grade II ankle sprain.

Times for the electromyographic response

Results related to the time for the electromyographic response obtained in the three groups can be seen in figure 3. It was found no statistical significance between right and left ankles in the group of healthy athletes (group 1), and between non-sprained ankles and the sprained ones from groups 2 and 3.

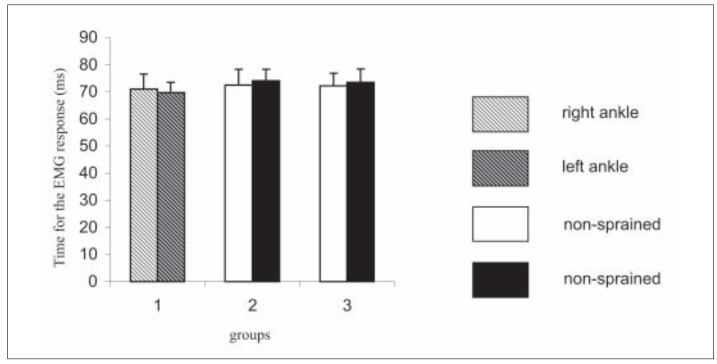

Fig. 3 – *Time for the electromyographic (EMG) response obtained in the three groups of the sampling*

Also, it was found no statistically significant difference for the results of the time for the electromyographic response having the eyes open, compared to the eyes closed in none of the three groups (figure 4 and 5).

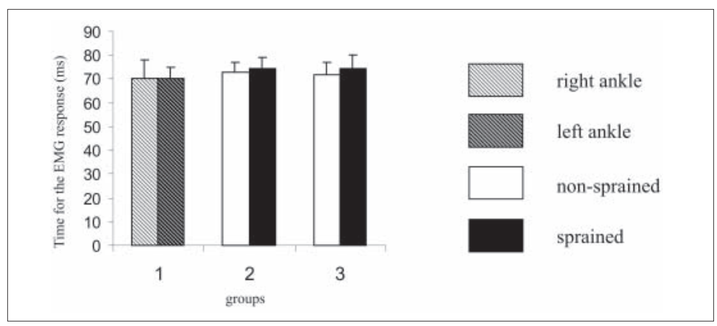

Fig. 4 – *Time for the electromyographic (EMG) response having the eyes open*

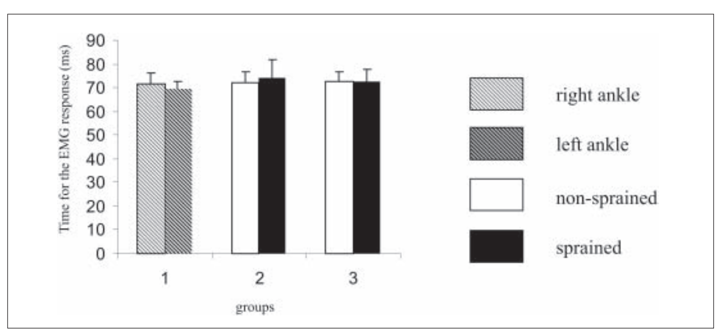

Fig. 5 – *Time for the eletrocmyographic (EMG) response having the eyes closed*

DISCUSSION

The sprain is considered the most frequent occurrence in the ankle articulation[1], mainly in sports involving jumps and falls, as in volleyball[1,4-6]. In this type of injury, the partial or total rupture of several tissues changes (or decreases) the athlete's proprioceptive ability[13-16]. Such reduction in the proprioceptive ability of an individual seems to be responsible by the reincidence in this type of injury[4,6,8,23,28,29]. To determine the time for the electromyographic response has been suggested as one of the ways to detect such reduction in the proprioceptive ability in an individual with ankle sprain[18,19]. This reduction in the proprioceptive ability should be manifested with an increase in the time for the electromyographic response in the muscles of the sprained portion compared to the muscles of the healthy portion[19,21,30].

A review in the literature revealed that there still are controversies on the subject, once some authors have presented evidences there is no changes in the times for the electromyographic response[3,8,13,20], while other works have shown that there is a delay in the time for the electromyographic response[19,21,30]. Having in mind the controversies presented in the literature as to the times for the electromyographic response, this study proposed to compare these times for the electrical response in the everter muscles (short and long fibular) of the athletes' healthy feet (group 1), and athletes and non-athletes with recent history of sprain by ankle inversion (groups 2 and). Assuming that the time for the electromyographic response would change with the ankle sprain, it was formulated three hypotheses.

Hypothesis 1 states that professional volleyball players with healthy ankles (G.1) would present a lower time for the electromyographic response than professional volleyball players with recent history of ankle sprain (G.2). Such hypothesis was not confirmed, having in mind that the results of the groups 1 and 2 presented no statistical differences. In the hypothesis 2 it was expected that the professional volleyball players with recent history of ankle sprain (G.2) would present a lower time for electromyographic response than non-athlete individuals with recent history of ankle sprain (G.3), having in mind the adaptations resulting from a long training period. Results for these groups did not present statistical differences as well, and therefore, that hypothesis was not confirmed as well. In hypothesis 3, professional volleyball players with healthy ankles (G.1) should present a lower time for the electromyographic response than non-athlete individuals with recent history of ankle sprain (G.3). Results did not confirm this hypothesis as well having in mind that it was found no statistically significant difference between both groups.

These results confirm what was found in the literature, that are in disagreement to the idea stated by Freeman *et al.* (1965)[28] where the mechanical instability would determine a functional instability of the ankle, causing a lack in the motor coordination (or even an increase in the time for the electromyographic response) due to the decreasing mechanoreceptor stimulus resulting from a ligamentous injury and/or of the articular capsule, which was not confirmed in these studies[3,8,13,20]. A possible explanation for other studies presenting a change in the time for the electromyographic response may be related to the inversion angle produced by the platforms used in those studies, which was of 30º[19,21,30]. In the present study and others which did not succeed in finding significant differences[3,8,22], the inversion angle used was only of 20º, since it was believed that this was a safe articular inversion angle to be used in individuals with recent injury. In such sense, this angle apparently was not big enough to reveal any changes in the proprioceptive ability of the sprained ankles.

The only exception to this case was a study using a 35º angle (that means, the wider angle used among all studies), but without finding any significant differences in the times for the electromyographic response[20]. It is not clear the reason for such difference related to other studies using a similar movement angle on the inversion platform.

Another important fact is related to the physiotherapeutic treatment, which probably could present an influence in the studies. The physiotherapeutic treatment that is helpful to the rehabilitation of the sprained articulation (in these studies, to the ankle articulation) was not mentioned by authors who found statistically significant differences, such as the rehabilitation factor of the sprains[19,21,30]. As those authors were working with times of the higher than six months ankle sprains, this makes us to believe that the lack of physiotherapeutic treatment has damaged the recovery of the sprained tissues, and this is in agreement to the studies reporting that the proprioceptive deficit may be found up to two years after the sprain, and so, the delay in the time for the electromyographic response shall remain[17] (table 1).

TABLE 1
Summary of the methodology found in the literature

Author(s)	EMG	Platform	Time of the sprain	Physiotherapy
Isakov *et al.* (1986)	surface	20°	2 months	No
Konradsen and Ravn (1990)	surface	30°	–	No
Karlsson *et al.* (1992)	surface	30°	6 months	No
Johnson and Johnson (1993)	surface	35°	3 months	Yes
Löfvenberg *et al.* (1995)	surface	30°	12 months	No
Ebig *et al.* (1997)	surface	20°	2 months	Yes
Sheth *et al.* (1997)	surface	20°	–	Yes
This study (2001)	surface	20°	4 to 10 weeks	Yes

Another interesting data related to other researches is that the results found in those studies seem to be meaningless, once the values found for the ankle groups with and without stability seem to be reverted, that is, higher values of the time for the electromyographic response were found within groups with no articular stability in the ankle (healthy ankles), while lower times for the electromyographic response values were found for sprained ankles[3,8,20,22]. Nevertheless, if the comparison is performed with studies presenting a statistical difference, results found by those authors seem to present some logic, once that lower values in the times for the electromyographic response were found in non-sprained ankles, and the higher ones were found in sprained ankles[19,21,30].

CONCLUSION

The findings of this study suggest that the times for the electromyographic response to the fibular muscles are not influenced by the ankle sprain. It is believed that these results were influenced by the lower than 30º angle of the platform, according to what is observed in the discussion of the article. It is suggested to perform studies using 30º angle platforms, similar to what was found in the literature with studies focusing the analysis of the delay in the time for the electromyographic response.

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Our relatives. Our parents, wife, husband, and daughter(s).

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