Use of ankle bracing for volleyball activities

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ABSTRACT

The ankle sprain is the most frequently found acute injury in volleyball. Aiming to prevent the occurrence of ankle injuries, prophylactic equipment as the bracing had been developed. This study had the purpose to evaluate the performance of the ankle muscles (tibialis anterior, peroneous longus, and medial and lateral gastrocnemius) by measuring the electrical activity in different volleyball activities (vertical jumping and lateral shuffling) with and without using ankle bracing. Nine young female volleyball athletes with ages ranging from 14 to 17 years ($\bar{x}$: 15.8 ± 1.3) were evaluated, all of them without previous injuries in the dominant member. Maximal voluntary isometric contractions (MVIC) of each muscle was collected, and after that, the electromyographic activity in different situations with and without using the bracing, randomly. The bracing used had two lateral supports. The electromyographic signal was quantified by the root mean square (RMS), and normalized by the MVIC. Analysis of the variance with repeated measurement was used to verify the difference of the electric activity of the muscles involved in each activity, with and without using the bracing, with 5% ($p < 0.05$) significance level. It was identified a statistically significant difference in phase I of the jumping in favor of the tibialis anterior ($p < 0.001$) and in phase II in favor of the three flexors muscles ($p < 0.001$; $p = 0.01$; $p = 0.003$) in both situations, with and without using the bracing. As to the lateral jump activity, a significant difference was observed in the phase of braked in favor of the tibialis anterior and the lateral gastrocnemius ($p = 0.013$) in both situations. It was found no statistical difference among muscles of the two groups. Results suggest that using the ankle bracing cannot influence the electrical activity of the muscles studied during the vertical jumping and the lateral shuffling.

Keywords: Ankle. Electromyography. Orthoptic devices.

INTRODUCTION

To participate in sports activities has been stimulated due to the benefits to the health. However, such practice predisposes the individual to specific injuries that may cause the removal of his daily activities, demanding a specialized treatment. Volleyball is a modality characterized by a great amount of repeated jumpings, both during defense movements (blockage) while arming pitch movements (lifting), and attack movements (some types of attack and game finalizations). Goodwin *et al.*[1] observed that 63% of the lesions in volleyball were related to the jumping.

The ankle sprain is the more frequent acute lesion found in this sports, with the incidence varying from 15 to 60%. The majority of the ankle sprains occur during the jump landing after a blockage or attack[2]. A review in the literature describes the means to prevent the ankle sprain: types of shoes, bandage, ankle bracing, and sensor-motor training.

The ankle bracing has the main purpose to promote an additional external support to the stabilizing ligaments and muscles of the joint. In a biomechanical investigation on the ankle stability using brace, it was verified an increasing in the torque of the joint of the ankle, thus neutralizing the inversion movement and keeping the joint in an appropriate anatomic position, with a better contact between the joint surfaces[4]. The ankle bracing can be classified as: lace-up (made by a flexible material, such as leather and strings to allow a better fixation), stirrup (with two lateral supports constituted by plastic material) and elastic[5]. Surve *et al.*[6] studied the efficiency of the bracing aiming to prevent the ankle sprains in soccer players. In such study, the author observed a lower incidence of sprains in the group of athletes with previous ankle sprain and using the bracing compared to the group that did not use it. Silter *et al.*[7] found similar results in a study with 1601 basketball athletes during two seasons. Some athletes with previous ankle sprain who used the bracing also obtained a lower occurrence of sprains in the joint.

Many studies have observed the effect of the bracings in the ankle muscles during sportive activities[8-10]. Hopper *et al.*[8] investigated the electromyographic activity of the gastrocnemius, the tibial anterior and the peroneus longus muscles during the jump using adhesive tape, and jump using bracing. In those individuals using bracing, there was a significant decreasing of the electromyographic activity of the gastrocnemius and the peroneus longus muscles. Cordova *et al.*[9] verified the effect of different bracings during stress in the inversion of the ankle by means of electromyographic signals in the gastrocnemius (medial portion), the peroneus longus, and the tibialis anterior muscles. Results confirmed the great importance of the peroneus longus as lateral stabilizer.

The aim of this study was to compare the electrical activity of the tibialis anterior, the peroneus longus, and the gastrocnemius muscles in volleyball athletes with and without using ankle bracing during two activities related to the volleyball (jumping and lateral displacement).

METHODS

Sampling

This study was composed by nine childish-juvenile female volleyball athletes of the Londrina Sports Foundation, aging from 14 to 17 years old ($\bar{x}$: 15.8 ± 1.3), with body mass index varying from 17.1 and 23.5 kg/m^2 ($\bar{x}$: 20.5 ± 2.4), and duration of training from 12 to 60 months ($\bar{x}$: 40 ± 15.3). This study used the convenience sampling. All participants signed a term of free and clarified consent duly analyzed and approved by the Committee of Ethics in Research of the Londrina State University (CEP 130/03).

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Received in 4/8/04. 2nd version received in 10/4/05. Approved in 12/6/05.

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Equipment

It was used a sixteen channel electromyograph (EMG System do Brasil) composed by a twelve bits A-D converter (analog-digital). Each channel was coupled to two active electrodes and a reference one. The circular silver/silver chloride electrodes were connected to a high impedance preamp (1.0 x 10^{12} Ohm) with common-mode rejection ratio 120 dB. Signals were fitted for 2000 sampling/sec, and the filter was adjusted in a 20 Hz to 500 Hz bandwith. These data were analyzed in data acquisition software (AqDados, 5.0).

Procedures

The electrodes (simple differential active of surface) were put on the muscle-tendon junction located by means of palpation of the muscular belly, and parallel to the muscular fibers, according to positioning described by Basmajian and Deluca[11]. The site was prepared with trichotomy and cleaned with alcohol to decrease the impedance. The reference electrode was placed on the wrist. The method used to perform the quantitative analysis of the electric potential amplitude throughout activities was the root mean square (RMS) expressed in microvolts (μV).

The procedure to collect the electrical signals started with the maximum voluntary isometric contractions (MVIC), with the purpose to normalize such signals. MVIC of the tibialis anterior and the peroneus longus were acquired by means of the muscular function assessment, according to Kendall and McCreary[12], with the manual resistance performed by the same appraiser in every athlete. As to the gastrocnemius (both portions), MVIC was accomplished having the participant stand up under a transversal bar fixed to the wall, and applying strength in such a direction as to rise the bar with the shoulders. From the MVIC values, the percentage of the electrical activation performed by the muscles was calculated in every activity proposed.

Protocol

After collecting the MVIC, all individuals were analyzed in two different activities: vertical jumping (with a preparation movement – countermovement), and lateral displacement (defense movement) with and without bracing. Such bracing (stirrup type, Aircast Sports-Stirrup, Summit, NJ) has a contact base to the foot in which two lateral extensions are lifted around 15 cm up to the middle of the leg. They are fixed by means of two double stripes (velcro).

Firstly, the jumping was performed having the athlete in bipedal support (with hands fixed on the waist), and the feet parallel and separated approximately at the height of the shoulders.

After a verbal sign, the participant performed the movement inflecting the hip and knee joints, and extending the ankle joint (phase 1 – descending or pre-impulsion). In the next phase (2 – ascending or impulsion) the participant performed a continuous movement in which the hip and knee's joints were extended and the ankle's were inflected.

The movement should be performed as fast as possible. The third phase analyzed was considered when the participant touched the ground (landing). The lateral displacement was performed by means of two continuous lateral shuffling towards the predominant side of the athlete: initially, the athlete started from the rest, stood up, extending the lower limbs, and next, performing the trunk flexion concomitant to a flexion of the knee, thus producing a passive extension of the ankle (closed chain) (phase 1 – beginning of the displacement). After that, the athlete propelled herself to the side with two jumps in a row performing a finalization as observed in the volley's defense movement (phase 2 – brake). The order of the activities and use of bracings (before or after) was randomized in each participant. For the data collection, all participants performed three repetitions of each activity. The two activities proposed (vertical jumping and side displacement) were recorded by an S-VHS camera (JVC) with the purpose to synchronize the interpretation of the electromyographic signal with each phase of the activities, thus allowing a better description of each muscle. The athletes were allowed to train the activities, as to warm and adapt themselves.

Statistical analysis

First, it was accomplished a descriptive analysis of the results (presented in MVIC percentages – average and standard error). In order to verify the differences of the electrical activity in the muscles involved in each activity with and without bracing, it was used the analysis of variance with repeated measures. It was applied the test of the Mauchly W.'s sphericity test, and whenever the test was violated, it was performed the necessary technical corrections through the Huynh-Feldt test. Whenever the F test was significant, the analysis was complemented by means of the Bonferroni's multiple comparison test. The statistical significance was adopted in 5% ($p < 0.05$). For the data analysis, it was used the Statistical Package for Social Sciences (SPSS) software version 11.5 for Windows.

RESULTS

The electrical activities of the muscles involved (tibialis anterior, long fibular, and gastrocnemius – medial and lateral portions) in each phase of the vertical jumping as well as the lateral displacement are exemplified in figures 1 and 2. The tibialis anterior muscle in phase 1 of the jumping has an electrical activity higher than the peroneus longus and the two portions of the gastrocnemius muscles in both situations – without and using the bracing ($p < 0.001$). In phase 2 of the jumping, the three flexor muscles with electrical activity higher than the tibialis anterior also in both situations – without and using the bracing ($p < 0.001$; $p = 0.01$; $p = 0.003$). In the third phase of the vertical jumping (landing) it was not identified a statistically significant difference between the electrical activities of muscles in both situations.

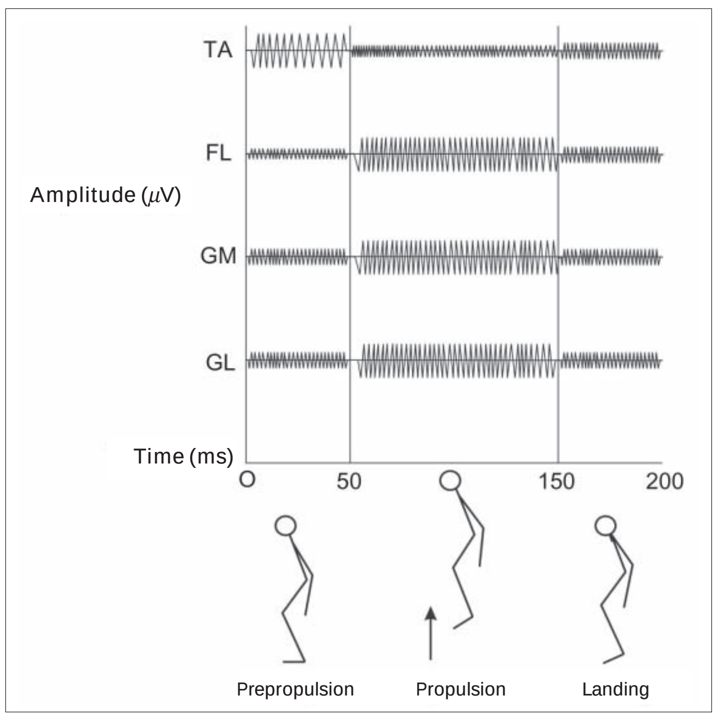

***Fig. 1** – Schematic figure of the electromyographic activity of the following muscles: tibialis anterior (TA), fibular longus (FL), and gastrocnemius – medium portion (GM) and lateral (GL) during the three phases of the jump.*

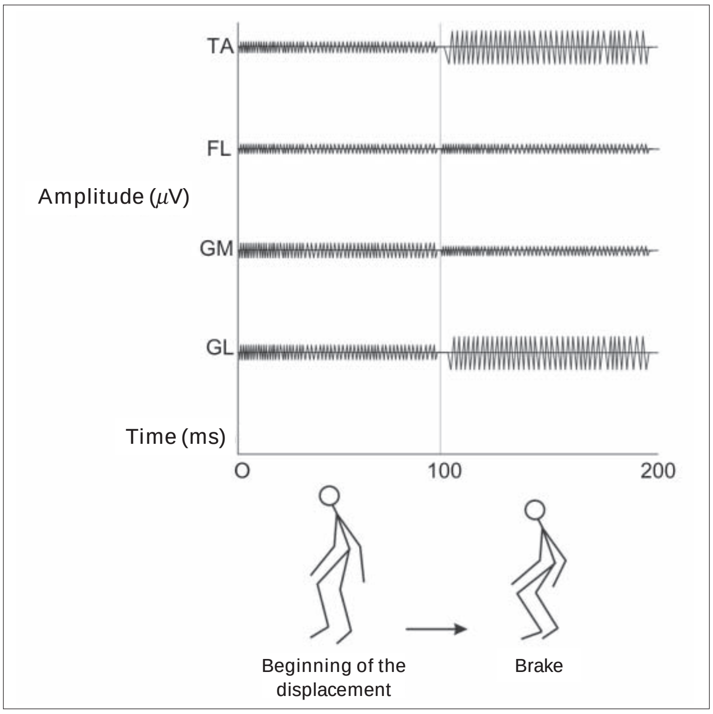

Fig. 2 *– Schematic figure of the electromyographic figure of the tibialis anterior (TA), fibular Longus (FL) e Gastrocnemius – medium portion (GM) and lateral (GL) during the two phases of the lateral displacement.*

As to the electrical activity of the lateral displacement, it was observed only one statistically significant difference between the tibialis anterior muscle and the medial portion of the gastrocnemius muscle in the brake phase in both situations using the bracing (p = 0.013). The MVIC percentages for each muscle in different phases, and the comparison using or not the bracing are presented in table 1 and 2. It was found no statistically significant differences between the two groups.

CHART 1
Mean ($\bar{x}$) and Standard Error (SE) of the CIVM's % of each muscle, phases I, II and III of the vertical jumping (prepropulsion, propulsion, and landing) of groups without and with using ankle bracing (n = 9)

	G. w/out bracing $\bar{x}$ (SE)	G. with bracing $\bar{x}$ (SE)
Vertical Jump		
Phase I – Prepropulsion		
Tibialis Anterior	78.9 (4.7)	90.1 (10.3)
Fibular Longus	36.2 (4.9)	44.2 (6.6)
Gastrocnemius (P. Medium)	30.4 (5.1)	29 (5.1)
Gastrocnemius (P. Lateral)	56.2 (21.3)	45.8 (13.2)
Phase II – Impulsion		
Tibialis Anterior	43.6 (5.7)	48.6 (7.6)
Fibular Longus	102 (3.6)	102.5 (3.6)
Gastrocnemius (P. Medium)	89.9 (6.1)	93 (8)
Gastrocnemius (P. Lateral)	91.7 (97.1)	97.1 (7.5)
Phase III – Landing		
Tibialis Anterior	72.7 (8.7)	81 (9.9)
Fibular Longus	62.9 (4.1)	67.7 (5.1)
Gastrocnemius (P. Medium)	89.9 (6.1)	93 (8)
Gastrocnemius (P. Lateral)	94.2 (14.5)	93.1 (14)

Groups were compared through the ANOVA with repeated measures.
Phase 1 (Huynh-Feldt Test for sphericity of p = 0.677; *F* Test = 0.047; p = 0.832). Phase II (Mauchly W Test for sphericity of p = 0.225; *F* Test = 0.111; p = 0.953). Phase III (Mauchly W Test for sphericity of p = 0.096; *F* Test = 0.100; p = 0.960).

CHART 2
Mean ($\bar{x}$) and Standard Error (SE) of the CIVM's % of each muscle, phases I and II of the lateral displacement (beginning and brake) of groups without and with using ankle bracing (n = 9)

	G. w/out bracing $\bar{x}$ (SE)	G. with bracing $\bar{x}$ (SE)
Lateral Displacement		
Phase I – Beginning		
Tibialis Anterior	47.9 (6.7)	53.8 (8.6)
Fibular Longus	49.9 (8.4)	51.3 (8.3)
Gastrocnemius (P. Medium)	70 (9.2)	70.2 (9.8)
Gastrocnemius (P. Lateral)	99.1 (14)	90.5 (10.6)
Phase II – Brake		
Tibialis Anterior	48.8 (6.1)	49.1 (8.8)
Fibular Longus	38.6 (6.1)	30 (4)
Gastrocnemius (P. Medium)	29 (2.5)	30.6 (4.8)
Gastrocnemius (P. Lateral)	48.1 (16.7)	42.9 (7.6)

Groups were compared through the ANOVA with repeated measures.
Phase 1 (Huynh-Feldt sphericity Test of p = 0.547; *F* Test = 0.031; p = 0.863). Phase II (Huynh-Feldt sphericity Test p = 0.632. *F* Test = 0.195; p = 0.664).

DISCUSSION

The vertical jumping and the lateral displacement are quite common sportive movements in volleyball. The jump is a frequent activity related to more incident muscle-skeletal sprains in such sports, and among them, the ankle sprain. Aiming to prevent the occurrence of this type of lesion, prophylactic equipments were developed such as the ankle bracing. This study has proposed to investigate the electrical activity of three muscles of the leg (tibialis anterior, peroneus longus, and gastrocnemius) in female volleyball athletes during two different situations, with and without an ankle bracing.

It was found no statistically significant difference in the electrical activity of the three muscles studied with or without using the bracing during bipedal vertical jumping.

This result is different from other results found in a studied performed by Hopper *et al.*[8], where the author verified a significantly decreased electrical activity of the peroneus longus and the medial gastrocnemius muscles whenever the individuals of the research used the bracing during one-leg landing movement.

In this research, it was studied the bipedal jump in three different phases: pre-impulsion, impulsion and landing. Hopper *et al.*[8] studied only the landing and in one-leg support with a different bracing than the one used in this study. Another difference of methods was that in our study, the athletes performed the jumping only in vertical direction, while in the previous study the athletes performed a vertical jumping with horizontal component.

Tillman *et al.*[13] studied the jumping and landing techniques in elite athletes of female volleyball. In this study, the author verified that 55% of attack landings and 57% of the defense landings are performed with symmetrical support from the two lower limbs (bipedal), as used in our research. However, the landing using one-leg support is described as a potential mechanism of sprain in the knees and ankle for volleyball athletes[14]. This aspect suggests the need to evaluate the electrical activity of the muscles studied also during the jump and the landing in one-leg support, and such aspect was not mentioned in this study.

Compared to the electrical activities of the muscles studied during the three phases of the vertical jumping described, it was observed in the phase 1 (pre-impulsion) that the tibialis anterior presents a higher electrical activity than other muscles. This result may be understood by the fact that the individual performs a hip and knee flexion associated with a passive extension of the ankle in closed kinetic chain, demanding a higher activity of the ankle extensor studied (tibialis anterior).

In phase 2 of the vertical jumping, or impulsion, the flexor muscles of the ankle are more requested due to an active flexion movement of that joint. So, it was observed a higher electrical activity in the two portions of the gastrocnemius and the peroneus longus.

Finally, in phase 3 of the jumping it was observed a higher electrical activity of the ankle flexors due to the eccentric contraction in closed kinetic chain after touching the ground, but it had no statistical significance.

Cordova *et al.*[9] studied the electric activity in the peroneus longus, the tibialis anterior, and the medial gastrocnemius during the lateral displacement. The author found a significant reduction in the electrical activity of the peroneus longus upon the use of both types of the studied bracing. In this study, it was found no statistically significant difference in the electrical activity of the muscles evaluated during the lateral displacement compared to the two situations studied (with and without bracing).

In the Cordova *et al.*[9] study, individuals were asked to perform five to seven consecutive high speed displacements, and as soon as their foot got in touch with a platform, they should change the direction of the displacement quickly, coming back to their original position. In this study, the request did not include high speed movements nor changing in the direction, what would explain different results found. The fact that there was no study on sudden deceleration during the side displacement performed in this research must be taken into account, since the peroneus longus muscle could be more requested during activities that stimulates the inversion stress.

While the athletes were performing the lateral displacement, it was observed that some of them were afraid to perform the activity due to the presence of wires of the electromyography channels connected to their legs. This aspect may have influenced the speed and the biomechanics of the movement performed by them. Such difficult was not detected during the execution of the vertical jump.

Compared to the electrical activity of the muscles studied during both phases of the lateral displacement described, it was observed that only in phase 2 (the brake) it has occurred a statistically significant difference in the electrical activity of the tibialis anterior and the medial portion of the gastrocnemius.

Another factor to be approached is the size of the sampling used in this study. The reduced number of individuals in the research may influenced the results obtained, causing the error type II. In this study, it was possible to note that the use of ankle bracing did not influence the electrical activity of the muscles studied during the two proposed activities.

CONCLUSION

This research found no statistically significant difference in the electrical activity in the muscle while accomplishing the two activities studied with and without using the ankle bracing. These results suggest that the use of ankle bracing may not influence the electrical activity of the three muscles studied during the vertical jumping and the lateral shuffling.

In order to better observe the activities studied, the authors suggest to perform new researches approaching sportive movements performed in one-leg support and high speed associated with changing in the direction with the purpose to evaluate the electrical activity of the muscles studied (with and without bracing) during situations closest to the sportive activity.

ACKNOWLEDGEMENT

The authors wish thank Prof. Roger Burgo de Souza of the Physiotherapy Division of the University Hospital of the Londrina State University for his support in supplying all the necessary material to the data collection (electromyography), Daniel Jose de Carvalho, Instructional Production and Scientific Division, Daniel from the University Hospital of the Londrina State University for manufacturing the figures, coaches Ney Inácio da Silva, and Carlos Alberto Hipólito of the childish-juvenile team of the female volleyball of the Londrina Sports Foundation, and the athletes who participated of this study. Without their collaboration, it would be impossible to accomplish this work.

All the authors declared there is not any potential conflict of interests regarding this article.

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