VERTICAL GROUND REACTION FORCES AND EMG DURING LANDING IN FUNCTIONALLY UNSTABLE ANKLE

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The purpose of this study was to compare vertical ground reaction forces (GRF) and electromyographic activity (EMG) from peroneus longus (PL), tibialis anterior (TA) and gastrocnemius lateralis (GL) of volleyball athletes with and without functional ankle instability (FI) during landing after a blocking maneuver. Synchronized EMG and GRF from 200ms prior to impact to 200ms after impact were acquired for 21 athletes with FI and 19 healthy ones. Results showed that FI subjects have a muscle activity that predisposes them to ankle sprains since PL presented lower RMS values prior to landing. GRFs were not different between groups.

KEY WORDS: ankle, joint instability, motor activity, electromyography, sports.

INTRODUCTION

The ankle sprain is one of the most common injuries in athletes, particularly in sports in which participants frequently jump and land on one foot like Volleyball (Thacker et al., 1999). 90% of ankle injuries in volleyball occur during landing after a blocking maneuver (Briner and Kacmar, 1997). The most common complication following ankle sprains is functional instability. Functional ankle instability (FI) has been defined as a tendency for the foot to give away after an ankle sprain with no evidence of ligament injury (Hertel, 2000). It has been reported that a history of ankle sprain is a strong predictor for the occurrence of ankle instability (McKay et al., 2001), and subjects with FI suffer recurrent ankle sprains (Konradsen *et al.*, 1998; Safran *et al.*, 1999; Hertel, 2000). The pathogenesis of FI.is considered to be multifactorial, with sensorimotor factors playing a role (Konradsen and Magnusson, 2000). The purpose of this study was to compare the EMG activation of selected lower extremity muscles and the vertical ground reaction force (GRF) of athletes with and without FI while landing after a volleyball blocking movement. We believe that subjects with FI present different temporal patterns and magnitudes of vertical forces sustained by unstable ankle and different muscular activation when compared to normal ones that can predispose them to recurrent ankle sprains.

METHODS

Data Acquisition: Forty subjects were studied (20.4±3.7 years), all of them professional volleyball players. Twenty-one subjects composed the functional instability group (FIG – 20.4±3.7 years) .They had complaints of FI with no evidences of mechanical injury, evaluated by anterior drawer and talar tilt clinical tests. Nineteen subjects composed the control group (CG – 20.3±3.8) and they had no complaints about instability and had no history of lower limbs injuries in the past six months. Informed consent was obtained from all subjects. The study was approved by the Local Ethical committee.
Ground reaction forces (GRF) and surface electromyography were acquired from peroneus longus (PL), tibialis anterior (TA) and gastrocnemius lateralis (GL) while subjects performed a jump similar to the volley blocking. Active bipolar electrodes (EMG System do Brasil, Brazil) were applied to record EMG (interelectrode distance: 25mm). The skin was shaved and degreased with alcohol to minimize resistance. Electrodes were placed on the muscle belly, far away from the innervation zone according to the European Concerted Action Surface EMG for a Non-invasive Assessment of Muscles (Hermens *et al.*, 2000). The EMG signals

were band-pass filtered (20-500Hz), amplified 1,000 times. A force plate (AMTI, USA) was used to measure GRF. GRF and EMG signals were simultaneously acquired using an A/D converter of 12 bits and they were sampled at 1000Hz.
The volleyball blocking manoeuvre was performed four times by each subject. This manoeuvre was simulated in laboratory environment, so it was executed without the volley ball. Subjects were instructed to perform the volleyball manoeuvre using the footwork technique they were more used to: the slide step or the cross-over step technique. All parameters were averaged across four trials. We analyzed EMG activity from 200ms prior to impact to 200ms after impact, both determined by vertical GRF. The raw EMG signals recorded were full-wave rectified and normalized by the maximal voluntary isometric contraction (MVIC). RMS values were obtained for each muscle in two different phases – (1) 200ms prior to impact, corresponding to the pre landing phase; (2) 200ms after impact, corresponding to the landing phase. The vertical GRF (Fy) was normalized by the body weight of each subject and we calculated: the force peak after impact (Fymax), time to force peak after impact (t Fymax), growth rate (GR Fymax= force peak /time) and impulse of the 200ms of the landing phase (Figure 1). Fymax was determined as the highest value achieved during the 200ms after impact. The variables from EMG and from GRF were calculated using a math function written in Matlab.

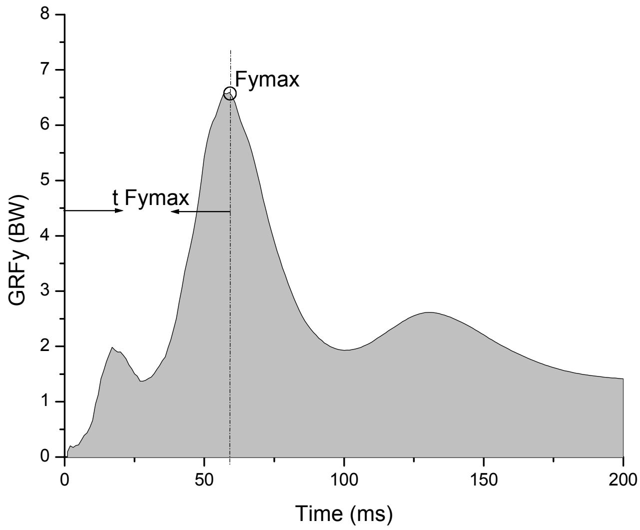

Figure 1: Graphic representation of mean vertical ground reaction force during landing and variables analyzed: vertical force peak (Fymax), time to force peak after impact (t Fymax) and impulse of the 200 ms of the landing phase (in gray).

Data Analysis: Data were processed using Matlab (version 6.5, Mathworks). Statistical tests were performed using SPSS for Windows (version 10.0). Variables were analyzed for normality with Shapiro-Wilk test. Groups were compared using T test for independent samples when normal distribution was present and using Mann-Whitney test when distribution was not normal (α=.05).

RESULTS

Results for RMS values are displayed in Table 1. Subjects with FI presented lower RMS values for PL muscle in the pre landing phase.
Results for GRFy are shown in Table 2 and Figure 2. There were no differences between unstable and control subjects in the force peak after impact, time to force peak after impact, growth rate or impulse during landing phase.

Table 1 RMS values of the studied muscles for control group (CG) and functional instability group (FIG)

	RMS values (%MVCI)			
	Muscle	CG (*n = 19*)	FIG (*n = 21*)	p
Pre-landing phase	TA	11.6± 6.0	13.0±9.4	0.468 (1)
	PL	43.0±22.0	26.2±8.4	0.003 (2)
	GL	45.0±21.8	42.7±21.8	0.370 (2)
Landing phase	TA	47.5±13.3	55.8±21.6	0.076 (2)
	PL	43.9±19.1	40.4±14.3	0.261 (2)
	GL	34.8±12.0	34.4±13.0	0.460 (2)

(1) Mann-Whitney Test
(2) Independent T-test

Table 2 Mean and standard deviation of vertical ground reaction force (BW – body weight) for control group (CG) and functional instability group (FIG)

Variables	CG (*n = 19*)	FIG (*n = 21*)	p
Fymax (BW)	5.18± 1.00	5.30±1.41	0.404 (2)
Δt Fymax (ms)	66.5±14.1	63.3±17.2	0.279 (2)
GR Fymax (BW/s)	87.2±41.2	107.0±72.0	0.282 (1)
Impulse (N.s)	0.4789±0.0572	0.4883±0.0567	0.318 (2)

(1) Mann-Whitney Test
(2) Independent T-test

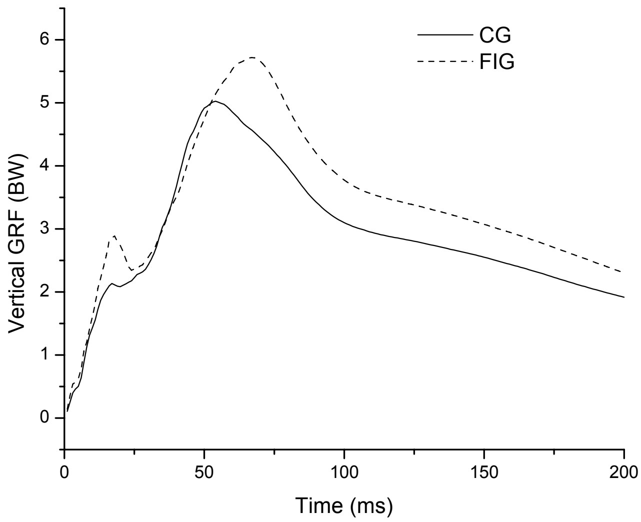

Figure 2: Graphic representation of mean vertical ground reaction force during landing for control group (CG) and functional instability group (FIG).

DISCUSSION

The results obtained in this study show a lower activation of the peroneus longus during the pre landing phase in subjects with functional instability. The pre-landing muscle activity reflects the strategy to prepare the muscles to absorb the impact whose time of occurrence and magnitude are anticipated by the central nervous system (Santello, 2005). This activity is considered essential to prepare the muscle-tendon complex for the rapid and forceful stretch after foot contacts the ground during landing and the subsequent joint rotations.

The peroneus longus is a potentially critical muscle in preventing ankle sprains injuries which activation functions as a protective mechanism to balance inversion (Neptune *et al.*, 1999). So, it is expected that this muscle activates satisfactorily prior to landing in order to provide some dynamic stability and protection against a possible ankle sprain. If in subjects with FI the peroneus longus is less activated prior to landing, these subjects can be predisposed to ankle sprains because PL may not be able to create an efficient eversor torque around the joint to prepare it to impact and, therefore, avoid an excessive inversion. If excessive inversion occurs, the individual can suffer a sprain or the feeling of giving way, the most common complaint of FI.

Patterns of the vertical component of GRF were similar in both groups as Caulfield and Garrett (2004) also found, showing that the condition of instability doesn't enhance impact. However, the main characteristic of FI is the tendency for the ankle to repeatedly sprain or give way. The ankle sprain is caused by an inversion associated with an excessive plantar flexion, so besides the vertical impact seems not to be enhanced by the condition of instability, probably this condition may be affecting the medial-lateral component of GRF, leading to a higher inversion and injury. The anterior-posterior and medial-lateral components of GRF should be studied in future in order to determine if the instability condition really does not affect dynamics.

CONCLUSION

Subjects with functional instability show a lower activation of the peroneus longus that may result in a reduction in protection against lateral sprains, since its main function is to evert the foot. Vertical ground reaction force seems not to be affected by the instability condition.

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