COMPARISON OF MUSCULAR ACTIVITY AND GROUND REACTION FORCE BETWEEN LAND–BASED AND AQUATIC JUMPING TRAINING

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SUMMARY
The benefits of jump-specific plyometric exercises have been studied in athletes and non athletes. Some authors have described the use of aquatic jumping training to obtain the same results, although this training generates a different stimulus. The aim of this study was to analyze the ground reaction force and the muscular activity of the muscles: rectus femoris, biceps femoris, and gastrocnemius during landing on two different ground conditions, land or swimming pool, after jumping from a height of 0.73 m. Nine Physical Education students took part in this study and performed 3 jumps for each condition, landing in the force platform. The data were obtained using a force platform and an electromyography of 8 channels (EMG System of Brazil). The analyzed variables were iEMG for each muscle and the peak force during contact with the force platform. To compare the differences between the trials it was used the statistics t test for dependent samples with significance level of 0.05. The results showed no significant differences in muscle activity for all the muscles, but a significant difference in peak force for the two conditions. Both findings seem to support the studies that propose the use of aquatic jumping training.

INTRODUCTION
The benefits of jump-specific plyometric exercises have been studied in athletes and non athletes. This training method has been associated with factors such as increased power output and maximum rate of force development as well as increased muscle fiber size, characteristics likely attributed to the stretch reflex, high eccentric loading, and explosive nature of plyometric exercises [1]. In the last years some authors [2,3] have described that the use of aquatic jumping training reduces the impact forces and increase the resistance to the movement. The results suggest that in comparison to the land-based, the aquatic jumping training could provide comparable training gains while providing a therapeutic modality for reducing muscle soreness and pain. On water the stress is considerably reduced because of its buoyancy that thus reduces stretch reflex, exercise velocity and the eccentric load over athletes’ joints which seems to generate a different stimulus, with different characteristics from the land-based plyometric training.

The aim of this study was to analyze the ground reaction force and the muscular activity of the muscles: rectus femoris, biceps femoris, and gastrocnemius during landing on two different ground conditions, land or swimming pool, after jumping from a height of 0.73 m.

METHODS
Nine Physical Education students took part in this study and were asked to perform three jumps for each condition. Jumps were performed from a squat position with heels on the surface and thighs in a horizontal position. Lower limb counter-movement and swinging of the arms were not allowed; the participants kept their hands on the waist, landing in the force platform and jumping out as quickly and forcefully as possible. The data were obtained using a force platform and an electromyography system of 8 channels (EMG System of Brazil), water resistant and of 12 bits resolution, with acquisition’s software and signals’ processing running under Windows operational system. Electromyographic (EMG) data were recorded using bipolar surface electrodes each consisting of two silver-silver chloride electrodes used on active EMG interface with a preamplifier system (x 20). The skin was abraded and then cleaned with rubbing alcohol prior to electrode placement. The electrodes were placed as suggested by Delagi [4] and each electrode pair was covered by a combination of adhesive waterproof tape and foam pad. This combination of waterproof material served to prevent water from contacting the skin-electrode interface.

The raw EMG signals were initially band-passed filtered from 20 Hz to 500 Hz and sampled at 1,000 Hz together with the force plate signal. The EMG data were then full-wave rectified, smoothed with a low pass filter at 5 Hz, normalized for each muscle to mean value found within each trial, and finally integrated.

The analyzed values were iEMG for each muscle and the peak force during contact with the force platform after landing in the two conditions – land and swimming pool (water). In order to compare the differences between the trials it was used the statistics t test for dependent samples with significance level of 0.05.

RESULTS AND DISCUSSION
The results (table 1) showed no significant differences in muscle activity for all muscles, but a significant difference in peak force for the two conditions. It means, in the swimming pool condition there was a lower load at the joints due to lower ground reaction force but the muscular activity was the same.
One variable very important in order to understand the results is the water depth. In accordance to several researchers [5] the percentage of weight bearing varies from 15% to 43% as the human body is immersed to the anatomical levels of C7 or the anterior superior iliac spine, what explains the observed lower ground reaction force in the swimming pool landing.

Table 1-Average values (Mean±std) for iEMG from rectus femoris (Rf), biceps femoris (Bf), gastrocnemius (Ga) and ground reaction force (Grf) for the two conditions: water (W) and land (L).

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>L</th>
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<tbody>
<tr>
<td>Bf</td>
<td>0.375±0.093</td>
<td>0.400±0.076</td>
</tr>
<tr>
<td>Rf</td>
<td>0.389±0.112</td>
<td>0.394±0.078</td>
</tr>
<tr>
<td>Ga</td>
<td>0.375±0.098</td>
<td>0.396±0.076</td>
</tr>
<tr>
<td>Grf (Kgf)</td>
<td>186.23±42.36</td>
<td>217.42±38.66*</td>
</tr>
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(*p≤0.05)

The literature also describes a decreased muscle activity while walking in water than when walking on dry land, related usually to changes in gait characteristics – lower stride frequency and lower stride length. But in examining average muscle activity within a gait cycle, during walking in water and on dry land, at subjects’ self selected speeds, it was reported that the biceps femoris activity while walking in water was higher. This might be related to the increased propulsive force needed to overcome drag force in water.

This can be also the explanation for our results. As we asked the subject to jump out as quickly and forceful as possible from the platform, even with less eccentric load acting over the subjects’ joints in the swimming pool, the force necessary to go forward generated the same muscular activity as in land based jumps.

The results are even more important when the literature [5] describes that it seems that the neuromuscular system achieved the same force output with less muscle activity in exercises in water.

CONCLUSIONS
Our results gives biomechanical support to the idea that the aquatic jumping training is an effective method of strengthening muscles and could be a good option for athletes in developing power, with lower possibility of risks and injuries when compared to the land-based plyometric training. For the aquatic training a special attention should be given to the water depth and to the motivational instructions during the training.

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REFERENCES