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HUMAN PHYSIOLOGY: ORIGINAL RESEARCH

Rebound boots change lower limb muscle activation and kinematics during different fitness exercises

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ABSTRACT

The purpose of this study was to evaluate electromyography and kinematic parameters of the lower limbs using rebound boots (RB) and barefoot during a gym workout. This information can be helpful to practitioners to schedule rehabilitation and training programs. Ten women (25 ± 9 years) volunteered for the study; inclusion criteria were as follows: subjects must have experienced the use of RB and the analyzed exercises for at least 6 months, and have no previous injuries in the lower limbs. Seven exercises were performed for 30 s with the RB and subsequently barefoot. Data from muscle activation of vastus lateralis (VL), biceps femoris (BF), lateral gastrocnemius (LG) and 2D kinematics were collected. The use of RB triggered postural changes, characterized by greater hip extension (in 4 of the exercises) and knee extension (in 6 of the exercises) for the landing. RB reduced activation mainly in LG (in 6 of the exercise) while no changes were observed for VL (except in exercise 1) and BF. RB change kinematics and muscle activation suggesting changes in the way the legs absorb and transmit force during jumps. LG was the main muscle affected by the use of RB.

1. Introduction

Sports that involve repetitive activities of running and jumping have higher rates of injuries in the lower limbs (Bennell et al., 1996; van Gent et al., 2007; Lopes et al., 2012). The main risk factors for these injuries are changes in joint angles and impact forces (Dufek and Bates, 1991). Alternatively, to minimize these risk factors, footwear with soles composed of springs (rebound boots – RB) have been considered for running activities assuming that these shoes could help in reducing impact forces (Newton et al., 1995; Vance and Mercer, 2002), and incidence of lower limb injuries (Miller et al., 2003). However, due to its design, the RB reduce mobility in the ankle joint - and may decrease muscle activation amplitude and consequently influence force production during impact absorption (Hume and Gerrard, 1998).

RB are popularly used in outdoor activities (especially in jogging) as well as indoor activities such as gym workouts involving vertical jumps. Despite the lack of studies addressing the influence of RB on the performance of jump exercise, depth jumps and counter movement jumps performed in rigid and elastic surfaces or springs differ (Crowther et al., 2007; Sanders and Wilson, 1992). Jumps performed on elastic surface (mini trampoline) resulted in smaller squats (larger extensions of the ankle, knee and hip) than when performed on rigid surfaces. Furthermore, Sanders and Wilson (1992) showed that landing on elastic surfaces resulted in a more extended position of the lower limbs compared to a rigid surface, which contribute to higher impact forces.

Regarding reduction in joint range of motion (ROM), Brizuela et al. (1997) analyzed running and jumping performance with different types of shoes (barefoot, shoes with low support and shoes with high support), and observed that the use of the shoes with high support affected the performance. Bobbert (2001) observed that the ankle joint has a key role in the release of elastic energy during the takeoff phase of a vertical jump, which would explain the lower performance in activities that depend on

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the effective stretch-shortening cycle (SSC). On the other hand, Smith et al. (2016) observed that the use of flexible orthotics in the ankle joints of football players, reduced joint mobility, further resulting in lower electrical activity of the soleus muscle while performing the vertical jump (CMJ).

Whereas RB [Kangoo Jumps (see Fig. 1)] present a design that facilitates the absorption and transfer of elastic energy (Newton et al., 1995; Miller et al., 2003), its design may impair the movements of the ankle joint, suggesting that the neuromechanical patterns involved in the production and regulation of movements can change with this type of footwear. Thus, by changing the range of motion, patterns of activation of the leg muscles (Walker et al., 2011) can also be changed, generating distinct stimuli to the practitioner, especially in fundamental movements like jumping.

Considering the popularization of the RB, there are few studies that address the neuromechanical aspects in the production and regulation of movements. This information can be helpful to practitioners to schedule the rehabilitation and training programs. Therefore, the aim of this study was to compare joint movements and muscle activation patterns in exercises performed in RB and barefoot conditions, in women who already had experience using RB. The main hypothesis of this study is that the use of RB, due to its characteristics, can reduce the electrical activity of the muscles of the lower limbs, in addition to modifying the kinematic motion patterns.

2. Methods

2.1. Participants and experimental design

Ten women participated in this study (mean and standard deviation for age 25 ± 9 years; body mass 62 ± 9 kg; and height 1.63 ± 0.06 m). Inclusion criteria were absent of injuries in the lower limbs and more than six months of experience using the RB in pre-choreographed fitness classes. All ethical aspects were respected and approved at the institution where the study was developed (protocol number: 25239013.6.0000.5020).

Fig. 1. The rebound boot (Font: www.kangoojumps.com).

2.2. Evaluated exercises

The participants performed seven pre-choreographed specific exercises in classes. These exercises were conducted in two conditions: wearing RB and barefoot (see Fig. 2). Each exercise was performed during 30 s, but for the analysis of EMG and kinematics, the intermediate 10 s were considered. There were ten repetitions evaluated for each assessed exercise. The speed of movement execution was controlled by the musical rhythm, and the same soundtrack was used for both conditions.

2.3. Acquisition of kinematic variables

Kinematic variables analyzed in this study were the relative flexion and extension of the hip (angle between the trunk and thigh segments), knee (the angle between the thigh and leg segments) and ankle (angle between the leg and foot segments). The 180° angle represented the full extent of the hip and knee; 90° was considered the neutral position of the ankle. In all seven exercises tested, the hip, knee and ankle angles in three stages were considered for analysis: stage 1.) The moment when the right knee showed maximum flexion during the swing phase (SP); stage 2.) The moment of first contact of the forefoot with the ground (FCG); and stage 3.) The moment when maximum knee flexion occurs during contact with the ground, also called landing (L) (see Fig. 2). Moreover, the range of motion (ROM) was determined in each condition (RB and barefoot), defined as the difference between the angles on the SP and L.

Images were acquired at the sagittal plane using two-dimensional videography (Camera Panasonic Lumix FZ200) and a sampling rate of 120 Hz. The camera was positioned 1.5 m away from the area where the participants performed the exercises. Reflective markers were placed on the right side of the body, at the following points of anatomical reference: fifth metatarsal, lateral malleolus, lateral epicondyle of the femur, greater trochanter and acromion process. Image scanning was performed using a kinematics software (Kinovea 0.8.15 Joan Charmant & Contrib.) for determining the angular variables.

2.4. Acquisition of the EMG signal

The muscles selected for this study were vastus lateralis (VL), biceps femoris (BF) and lateral gastrocnemius (LG). Passive bipolar electrodes 42 mm long and 20 mm wide (Double Hal, Porto Alegre, RS, Brazil) were set parallel to the orientation of the fibers between the motor point and the distal tendon from the right leg. Before attaching the electrodes, the skin was prepared according to the guidelines of SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) (Hermens et al., 2000).

The surface electromyography signals (SEMG) were recorded at the sampling rate of 1500 Hz (Noraxon MyoSystemTM 1400A). The Root Mean Square (RMS) was determined through fixed time intervals, located in the 10 s of the central collection of the seven exercises assessed and in both conditions (RB and barefoot). For presentation purposes and the comparison between conditions, the EMG signals used the RMS average of the analyzed intervals. In all evaluated exercises as well as between conditions, the electrodes were maintained in the same position. For the analysis of