KINEMATIC ANALYSIS OF KETTLEBELL SWING IN DIFFERENT SURFACES – COMPARISION BETWEEN STABLE AND UNSTABLE SURFACES

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The purpose of this study was to characterize the kettlebell swing movement kinematics, and to examine the changes induced by an unstable surface. One experienced subject with a 6kg kettlebell performed 10 kettlebell swings on the floor and 10 on an unstable surface. Optoelectronic system with 6 cameras was used to obtain the 3D analysis. Four variables were selected for this pilot study: the leg-thigh and the thigh-trunk angles when the subject had the maximal knee joint flexion, the arm-trunk angle when the subject was at maximum extension of the knee joint and the duration of the trials. Significant changes induced by the unstable surface were obtained in the four variables selected. Thus, this study presents a simple, operation and low-time consuming process to evaluate the role of unstable surface for fitness exercises. Further studies should deeply examine different surfaces, to clarify its role in rehabilitation programs.

KEY WORDS: kinematics, unstability, fitness, rehabilitation.

INTRODUCTION: The kettlebell (KB) was used in Russia since 1700's as a counter-weight for market product scales and later was used by athletes, lifting and swinging the KB (Brumitt, Gilpin, Brunette, & Meira, 2010; Kim, Back, Joo, Park, & Moon, 2016). In most recent years, the KB has reaching levels of high populism as a piece of training equipment due to the growth of CrossFit®. There are two types of swinging the KB. First, the Russian one which involves a hip hinge flexion movement with the kettlebell hiked between the legs and then aggressively swung forward with hip extension as the movement propels the kettlebell to the top position at approximately chest height (Lake & Lauder, 2012). The second one (American swing) has become popular as the preferred swing movement of CrossFit®. The American swing involves hiking the kettlebell backward with a squat movement and then swinging the kettlebell above the head (Brumitt, Gilpin, Brunette, & Meira, 2010).

Despite different studies used the KB swing to show and compare this movement as a strength and conditioning alternative (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012; Jay, et al., 2013; Lake & Lauder, 2012; McGill & Marshall, 2012; Thomas, Larson, Hollander, & Kraemer, 2014) just one look to this movement as a component in a rehabilitation program to restore and increase the range of motion, power and strength of the patient (Brumitt, Gilpin, Brunette, & Meira, 2010). From all the studies just one had the objective to analyse the kinematics of the KB swing (Kim, Back, Joo, Park, & Moon, 2016) and no studies were made relating the KB swing kinematics in different surfaces.

The use of unstable surfaces in training or rehabilitation reduce or eliminate an individual's points of contact with solid ground (Cressey, West, Tiberio, Kraemer, & Maresh, 2007), decreasing the balance of the human body which has a fundamental component to perform any physical movement (Ruiz & Richardson, 2005). This lead to a change in human movement by changing the angles and muscle groups used.

The purpose of this study was to compare the KB swing movement in stable and unstable surfaces and to find the differences between them.

METHODS: One fitness practitioner (height, 176cm; mass, 72Kg; age, 25 yrs) with experience of KB swing exercise participated voluntarily in this study. The subject was in perfect health and no injury in last 12 months at the time of data collection. Subject admitted their acceptance on a consent form prior to experiment.

Data were collected using a Motion Capturing System (NaturalPoint Inc., Corvalis, OR, USA) consisting on 6 InfraRed cameras and a data-collecting software (Motive, NaturalPoint Inc., Corvalis, OR, USA). 34 reflective markers were attached on body based on the skeleton pre-defined by Motive software. The mass of the KB was 6kg and for simulate an unstable surface a Bosu ball (Bosu, Ashland, OH, USA) was used. When preparation was finished and after a 10min warmup, the subject performed 10 repetitions of the American KB Swing with and without the Bosu ball (Figure 1). The motion data passed through a digital filter (Buttherworth 2nd order low-pass filter with a cut-off frequency of 7Hz) before data analysis. Three joint angles (leg-thigh angle, thigh-trunk angle, arm-trunk angle) and time of each repetition were analysed using Visual 3D software (C-Motion, Germatown, MD, USA). The leg-thigh angle and the thigh-trunk angle were analysed when the subject had the knee joint in maximal flexion and the arm-trunk angle was analysed when the subject was at maximum extension of the knee joint. For the study of the above mentioned articular angles, the inner relative angles between segments were analysed and these were calculated in the perpendicular plane to the studied movement. 20 repetitions (10 in stable surfaces and 10 in unstable surfaces) were performed for analysis. For statistical analysis of the data, SPSS (IBM, Armonk, NY, USA) software was used. Is was considered the type of the surface by creating 2 groups divided in stable and unstable surface. An independent-samples *t* test was performed to compare the means of both groups. A significance level of $p < 0.05$ was established.

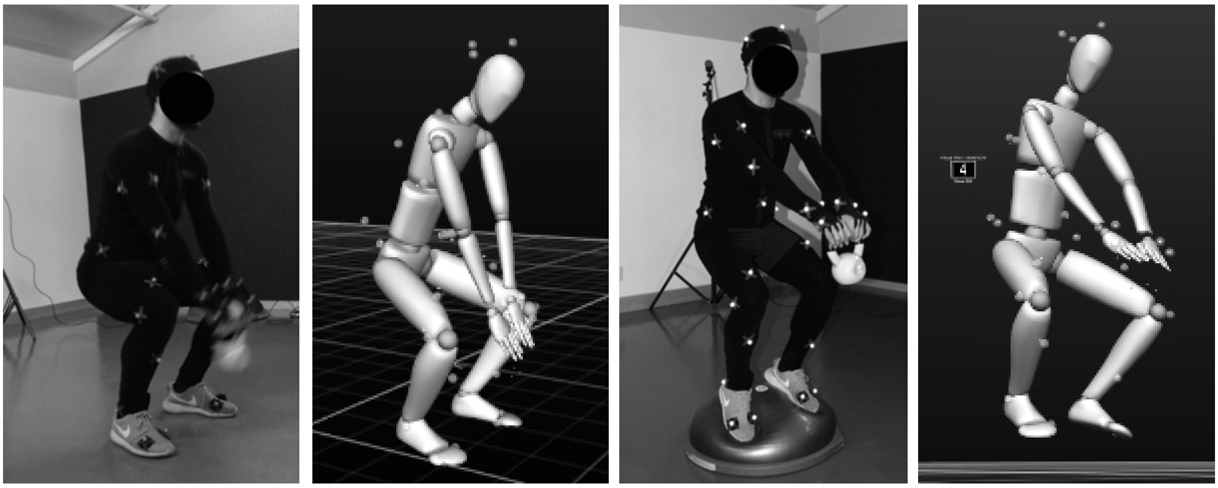

Figure 1. KB swing performed by the subject in stable and unsable surface with the 34 markers attached to the body and the skeleton model created in Motive Software.

RESULTS: Mean (±sd) values, and level of significance, of the studied variables are presented in Figure 2. It was noticed that the unstable surface induced lower leg-thigh and arm-trunk and higher thigh-trunk angles. Regarding the duration of the trials, with the unstable surface it has increased about 6%.

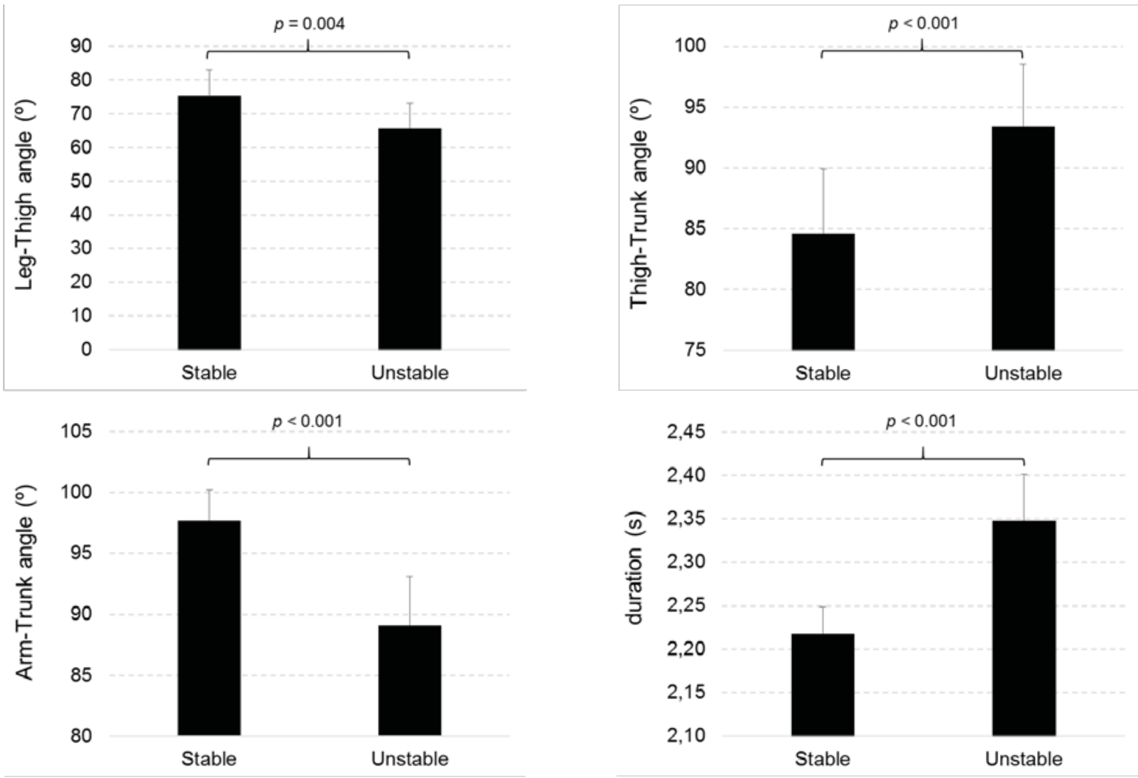

Figure 2. Comparison of the analysed angles and duration between stable and unstable surfaces.

DISCUSSION: The unique shape of KB allows to perform swinging movements, which are becoming an everyday routine in physical exercise programs, but also for rehabilitation. Performing this swing movement allows the subject to activate important muscles in the lower extremities, core, and the upper body (Brumitt, Gilpin, Brunette, & Meira, 2010). Thus, it may turn the body movement to an optimized lever system reaching not so easily trained muscles. Furthermore, using an unstable surface may require higher activity from lower-body muscles and core to stabilize the body centre-of-mass. The lack of stability for strength training in recent studies have already analysed squat in these conditions (Saeterbakken & Fimland, 2013). This type of movement seems to be limited to the greater activity of the trunk muscles due to the need to control the posture (Norwood, Anderson, Gaetz, & Twist, 2007), than the use of the lower limbs muscles where there is lower record of muscular activity when instability is imposed (McBride, Larkin, Dayne, Haines, & Kirby, 2010).

The results obtained in this study suggest that using an unstable surface may have influence in the KB swing movement. At the maximal knee joint flexion, the evaluated subject presented a lower value of the leg-thigh angle and a higher value of the thigh-trunk angle. Theoretically, the latter was induced by the higher flexion of the lower limbs, aiming to maintain the balance. Moreover, this was followed by a lower range-of-movement of the KB with a higher duration. Therefore, we can assume that the subject adopted a much lower movement velocity. Also, the KB swing on the unstable surface seems to require more technique than on the stable surface and this should be taken in consideration to apply the KB swing to a rehabilitation program.

Comparing with the study of Kim, Back, Joo, Park, & Moon (2016) that compared the kinematics of KB swing between beginners and experts, major differences were found in the knee joint at maximal flexion and shoulder joint at maximal extension but identical values for the hip joint at maximal flexion. Despite the aforementioned study did not describe the KB swing movement used, its possible that the KB swing chosen was the Russian one instead of the American one used in this study. Limitations for the interpretation of the data reported in