EMG OF LOWER LIMB MUSCLES DURING KETTLEBELL EXERCISES

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The current study examined the differences of lower limb muscle activity during two different styles of kettlebell swings, hip-dominant and swing-dominant styles. Surface electrodes were placed on the rectus femoris, biceps femoris, semimembranosus, tibialis anterior, and gastrocnemius. Nine subjects performed a hip-dominant swing and a swing-dominant swing while electromyography data were collected. The data collected showed that there were no significant differences in muscle activation during the two swings when analyzing the results of the electromyography of the selected lower limb muscles. These findings suggest that there is no advantage to performing one style of swing over the other in kettlebell swing exercises during training.

Keywords: kettlebell swing, hip-dominant, swing-dominant

INTRODUCTION: The incorporation of kettlebells into exercise programs, particularly those involving strength and conditioning, is progressively growing in popularity despite the lack of in depth research about their use. The popularity is due to the variety of fitness areas the tool affects: including reduction of body fat and improvement not only of muscular strength and endurance, but also cardiorespiratory fitness (Harrison, Schoenfeld, & Schoenfeld, 2011). Unlike other methods of strength training, the use of kettlebells involves recruitment of the entire body and its movements as opposed to simply focusing on just one or two specific areas (Harrison et al., 2011). Due to its unique shape and ability to allow for a swing in an arcing motion, it serves as a potential method to not only develop strength and power, but also to develop flexibility and range of motion in a rehabilitation setting when recovering from injuries (Brumitt, Gilpin, Brunette & Meira, 2010).

While the use of kettlebells in rehabilitation settings is still being explored, their primary application is in the development of strength and power through swinging exercises (Brumitt et al., 2010). There are a variety of styles and applications in the use of kettlebells, specifically in the type of swing, which may result in a different focus depending on the specific training and goals (Brumitt, et al., 2010). The primary style of the kettlebell swing is the Russian, or hip-dominant swing style (Bearsley & Contreras, 2014). A less traditional, American or swing-dominant swing style, was developed that focused less on the actual hip movement and more towards the swing itself (Pender, 2014). Both have a very similar foundation in terms of the swing; however the actual swinging motions differ. The main position for both swings is standing so that the feet are approximately 1.5 times that of the shoulder width with the toes pointed out slightly laterally with both the knees and ankles in flexion (Jay, et. al, 2013). It is also crucial for the swing to be effective to ensure that the spine remains neutral and aligned with a square chest, shoulders pushed posteriorly (Pender, 2014). As the swing is started, the motion becomes explosive with the hips ‘snapping’ as the kettlebell is swung upwards. In the hip-dominant style, the kettlebell is swung to approximately eye level while in the swing-dominant style, the kettlebell is swung until it reaches above the head (Bearsley & Contreras, 2014) (see Figures 1 and 2).

Each style has a different focus and therefore different effects on the muscles. The purpose of this experiment was to analyze the muscle activity of five lower limb muscles: the rectus femoris (RF), biceps femoris (BF), semimembranosus (SM), tibialis anterior (TA), and gastrocnemius (GS) during the two different styles of kettlebell swings.

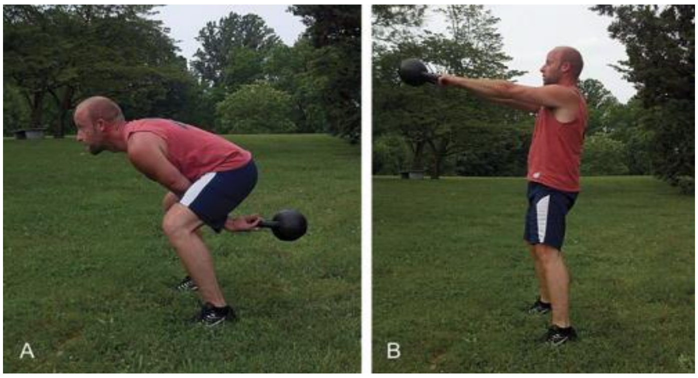

Figure 1. The “Russian Style” (Hip-Dominant) Swing, characterized by an emphasis on hip movement and a swing ceasing at eye-level (Harrison, Schoenfeld, & Schoenfeld, 2011).

Figure 2. The “American Style” (Swing-Dominant) Swing, characterized by the swing reaching above the eye level to above the head (Crossfit Station, 2014).

METHODS: Nine college aged, right leg dominant, women (mean ± SD: age = 21.4 ± 1.8 years; height = 164.3 ± 5.9 cm; and weight of 67.4 ± 9.6 kg) participated in the current study. Participants signed an informed consent form and completed a Physical Activity Readiness-Questionnaire prior to participating in the study. Approval by the Institutional Review Board was obtained (HS14-620) prior to commencing the study.
Each subject was fitted with a dual electromyography surface electrode (Noraxon, Scottsdale, AZ, USA) over the belly of the following lower limb muscles of their dominant leg: rectus femoris, biceps femoris, semimembranosus, tibialis anterior, and gastrocnemius. According to Cram and colleagues (1997), to prepare the skin for the electrodes and minimize skin impedance, the skin was primed prior to placement by rubbing an electrode prep pad over the area for a few seconds to clean the skin. The same area was then rubbed lightly with a small piece of sand paper, enough to abrade the skin and turn it a light pink color. The electrodes were then tested for skin impedance with an ohmmeter and confirmed to have a proper impedance level below 5,000 ohms. The EMG electrodes were then synced to the BTS FreeEMG 300 System (BTS Bioengineering; Brooklyn, NY) for data collection. A sampling rate of 1000Hz was used for data collection. Before any data were collected, the subject demonstrated proper posture and ability to not only lift the designated weight, but to also safely perform the swings. Prior to data collection, each subject performed a three minute warmup on an elliptical at a slow, yet steady pace. Subjects then completed maximal voluntary isometric contractions (MVIC) using a BioDex System 4 Isokinetic Dynamometer (Biodex Medical Systems; Shirley, New York) for each of the lower limb muscles against resistance (knee flexion, knee extension, plantar flexion, and dorsiflexion) to compare against EMG data collected during the swings.
To perform the hip-dominant swing, each subject held a 4.5 kilogram (10 pound) kettlebell with both hands in between their legs in a semi-squatting position. When prompted, using proper posture as described earlier, the subject swung the kettlebell until it was approximately at eye

level and let it fall back down between the legs before swinging again. A total of three swings were completed as EMG data were being collected.
To perform the swing-dominant swing, each subject continued to use the 4.5 kilogram kettlebell. When prompted, the subject once again swung the kettlebell, continuing the swing and stopping above the head before completing the motion back to the original position. A total of three swings were collected as data was being collected.
BTS EMG-Analyzer software (BTS Bioengineering; Brooklyn, NY) was used to analyze the electromyography data using a Butterworth high and low pass filter (at 10Hz and 450 Hz, respectively), rectification, and integration over a span of 50 milliseconds. Once all EMG data were collected, the mean integrated values were then compared to the MVIC to determine the percent of maximal contraction the muscle was engaged in. These values were then analyzed using two-way repeated measures ANOVA using SPSS v22 to determine any statistical significance.

RESULTS AND DISCUSSION: The purpose of this experiment was to analyze the muscle activity of lower limb muscles during two different styles of kettlebell exercises: hip-dominant and swing-dominant. The two-way repeated measures ANOVA comparing muscle activation of the muscles showed that there was no statistical difference ($p > 0.05$) between the two different swings (see Figure 3). One potential explanation is due to the squatting motion that the kettlebell swing imitates. During this squatting motion, as the swing returns to the position between the legs, both the tibialis anterior and gastrocnemius are activated to provide stability throughout the motion and maintain the erect posture that a kettlebell swing requires for effectiveness though the tibialis anterior is more principal to the motion (Dionisio, Almeida, Duarte & Hirata, 2008). While this motion occurs, lower limb muscles work to perform the squatting motion in the swing specifically through rapid eccentric control of the hamstrings, which is unique to kettlebell swing exercises (Bearsley & Contreras, 2014). This motion is one that is consistent throughout both styles of swings.

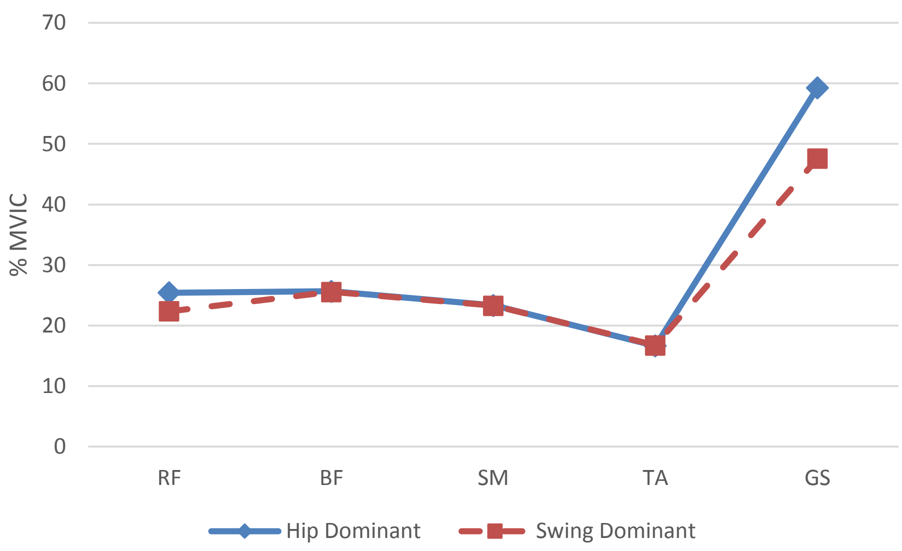

Figure 3. Mean % Maximal Voluntary Isometric Contraction (MVIC) for the Rectus femoris (RF), Biceps femoris (BF), Semimembranosus (SM) Tibialis anterior, TA, and Gastrocnemius (GS) during the hip-dominant and swing-dominant exercises.

Surprisingly, the percent of maximal contraction was low throughout most of the muscles analyzed on average with the exception of the gastrocnemius, which had almost double the percent maximum as the other four muscles analyzed (see Figure 3). However, statistical analyses revealed no differences across the muscles for EMG activity ($p > 0.05$). It is important to note that one subject had an extremely high percent of MVIC of the gastrocnemius that could have been a result of not truly performing an initial maximum contraction which inflated the variability. However, because subjects were compared to themselves this would not affect the significance testing. Furthermore, one aspect to these low values is the role that gravity is playing on not only the kettlebell, allowing it to fall, but also on the muscles (Dionisio, Almeida, Duarte & Hirata, 2008). The role that gravity plays may also explain why there might be a slight, but not significant difference in activity of these muscles during the swing-dominant exercise since the kettlebell has a further height to fall from and the muscles a deeper squatting position to fall into. One other factor that may influence the low values of MVIC is the low weight of the kettlebell used in the current study. Lake and Lauder (2012) suggest that increasing the weight of the kettlebell utilized in swing exercises not only increases the demand of the exercise through force and power output, but also in statistical significance as weight of the kettlebell increases.

The current study's data showed there is no significant difference in muscle activation when comparing both swings and muscles between swings, since no distinct trends were shown within and/or between muscles. These small percentages of MVIC corroborate recent suggestions that these kinds of swinging exercises might not help to improve maximum strength levels. This is likely due to the lack of high force overload stimuli. However, increases in generating power using kettlebell swings may be possible when incorporated in specific training protocols (Lake & Lauder, 2012).

CONCLUSION: The purpose of this experiment was to analyze the differences of lower limb muscles during two common, but differing types of kettlebell swings, hip-dominant and swing-dominant. Overall, the results showed that there was no statistical significance in muscle activation when comparing the two styles of swings. This suggests that on a general level, in regards to lower limb muscles, both swings can offer similar levels of muscle activation. Implications to applying kettlebell exercises in training regimes suggest that there is no significant advantage to performing one style of swing over another. The lack of extensive research in kettlebell training opens a plethora of opportunities for further research through examination of muscles in other parts of the body such as the upper limbs or trunk, which could be advantageous for training involving these areas. Furthermore, research could also reveal other applications that kettlebells can potentially have in a variety of settings.

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