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Research Paper Review

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Kettlebell swing, snatch and bottoms-up carry: Back and hip muscle activation, motion and low back loads

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ABSTRACT

The intent of this study was to quantify spine loading during different kettlebell swings and carries. No previously published studies of tissue loads during kettlebell exercises could be found. Given the popularity of kettlebells, this study was designed to provide an insight into the resulting joint loads. Seven male subjects participated in this investigation. In addition, a single case study of the kettlebell swing was performed on an accomplished kettlebell master. Electromyography, ground reaction forces (GRFs), and 3D kinematic data were recorded during exercises using a 16-kg kettlebell. These variables were input into an anatomically detailed biomechanical model that used normalized muscle activation; GRF; and spine, hip, and knee motion to calculate spine compression and shear loads. It was found that kettlebell swings create a hip-hinge squat pattern characterized by rapid muscle activation-relaxation cycles of substantial magnitudes (~50% of a maximal voluntary contraction [MVC] for the low back extensors and 80% MVC for the gluteal muscles with a 16-kg kettlebell) resulting in about 3,200 N of low back compression. Abdominal muscular pulses together with the muscle bracing associated with carries create kettlebell-specific training opportunities. Some unique loading patterns discovered during the kettlebell swing included the posterior shear of the L4 vertebra on L5, which is opposite in polarity to a traditional lift. Thus, quantitative analysis provides an insight into why many individuals credit kettlebell swings with restoring and enhancing back health and function, although a few find that they irritate tissues.

ANALYSIS

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Background Information

There is no doubt that the use of the kettlebell is becoming increasingly popular in the personal training and strength and conditioning worlds. Despite its popularity, a dichotomy exists with regard to their utility. Anecdotally, some lifters claim performing kettlebell swings will help ease their back pain and/or augment hip extension strength, while others claim that using kettlebells create or aggravate back injuries.

This study discussed the mechanics of various kettlebell swings, including the swing and swing-to-snatch exercises, both the racked-style and bottoms-up style carries, and the Kime lift (a swing with a punch and abdominal pulse at the top of the swing).

McGill and Marshall specifically wanted to answer 3 questions with this study:

1. Are there unique features of kettlebell swing mechanics which are perceived as therapeutic by some, and injurious to others?
2. What, if any, effect does the Kime movement have on muscle activation and loading of joints?
3. Do the bottoms-up and racked style carries have different muscle activation profiles for training?

PERTINENT RESULTS

Kettlebell Swing

Just the initial motion of the kettlebell swing activated the back muscles to a total of 50% maximal voluntary contraction (MVC). Peak activation of these muscles occurred approximately 30% into the swing. The peak abdominal activation was followed by gluteal muscle activation peaks. The gluteal muscles experienced their peak activation at 57% of their lifting cycle (76% of MVC). Abdominal muscles pulsed in a ballistic fashion midway through the swing. The kettlebell swing had a significant effect on 3 muscles in particular: right external oblique, right rectus femoris and left internal oblique. The activation of the right external oblique was, however, not significantly different from its activation during the other swings (this asymmetry is likely because all subjects were swinging the bell in their right hand).

Kime Swing

During the Kime swing, the external oblique muscles experienced their largest increase in activation at approximately 80% of the lift cycle (101% increase in right external oblique and 140% increase in the left external oblique). Spine, hip and knee kinematics, and spine loading were not incredibly different from the swing without Kime. The swing with Kime produced greater peak right rectus femoris and left internal oblique activation compared to the swing without Kime.

Swing-to-Snatch

The swing-to-snatch exercise increases the activation of almost all the muscles, due to the greater effort required to propel the kettlebell overhead. Spine compression, shear loads, and spine, hip and knee kinematics were similar to those of the other 2 swings.

Overall, spinal compression magnitudes were quite low, being < 3200N in all swings. The beginning of swing featured the greatest level of compression, regardless of the style of swing. However, the style of the swing had an impact on the level of compression at the end of the swing. The Kime swing resulted in 2960N of compression at L4/L5 at the end of the swing, while the swing without Kime produced 1903N at the same segment.

The type of swing also had influence on the amount of posterior shear of the L4 vertebra over L5. The Kime swing produced 267N of shear, whereas the swing-to-snatch produced only 78N.

Simply carrying the kettlebell either in the racked or bottoms-up position could have a positive effect on overall spine stiffness (not quantified in this study). All muscles except the left external oblique increased their activation while the bottoms-up carry was being performed (keep in mind, all lifts were executed in the right hand). Joint compression and shear load were significantly greater while executing the bottoms-up carry, compared to the racked position.

Pavel Tsatsouline, Russian kettlebell master, was also assessed in a case study format. He performed 2 different swings: a single-handed 32 kg swing without Kime and a double-handed 32 kg swing. While swinging with his right hand, he achieved 150% MVC of his left erector spinae muscles, and 100% MVC in his left glutes. He also stiffened the hip at the top of his swing, which prepares him for additional load and "superstiffness" (a term coined by McGill in various publications). This "superstiffness" technique is not recommended for those with back concerns or those in the general population who do not require "superstiffness" of the spinal column to augment performance. The double-handed swing produced greater symmetry between sides in the back and hip muscles, but produced lower activation magnitudes than the muscles of the left side during the single handed swing.

CLINICAL APPLICATION & CONCLUSIONS

Question 1: Are there unique features of kettlebell swing mechanics which are perceived as therapeutic by some, and injurious to others?

- There is a large interplay between low back compression and shear that is not observed during exercises such as the squat or lifting a bar that are extension dominant. The centrifugal forces produced by the kettlebell swing that are required to accelerate the bell through its arc cause high posterior shear forces in relation to compressive forces. This may be why some powerlifters may be relatively asymptomatic while performing their traditional lifts – *therefore, if they are intolerant to shear forces through the low back, then perhaps kettlebell exercises should not be performed because they may not be helpful.*

- It appears as if the kettlebell swing requires sufficient spinal stability. Additionally, if the lifter is not properly ensuring a close-to neutral spinal posture while executing the lifts under load (i.e. lifting in lumbar spinal flexion), this could lead to disc injury; although, this is modulated by a number of variables (1). *The moral of the story here is, ensure that your athletes are in spinal neutral while under load – utilize the hip hinge.*

Question 2: What, if any, effect does the Kime movement have on muscle activation and loading of joints?

- Loads in the low back were different between different forms of swing.
- The exercise facilitates the rapid contraction-relaxation relationship required for powerful movements.

Question 3: Do the bottoms-up and racked style carries have different muscle activation profiles for training?

- The bottoms-up carry imposes greater challenge to the core musculature. The researchers speculate that this is due to the fact that stiffening the core enhances grip strength (2); more core control is needed to carry the kettlebell while it is being held in the bottoms-up position.

STUDY METHODS

This study was separated into 2 parts:

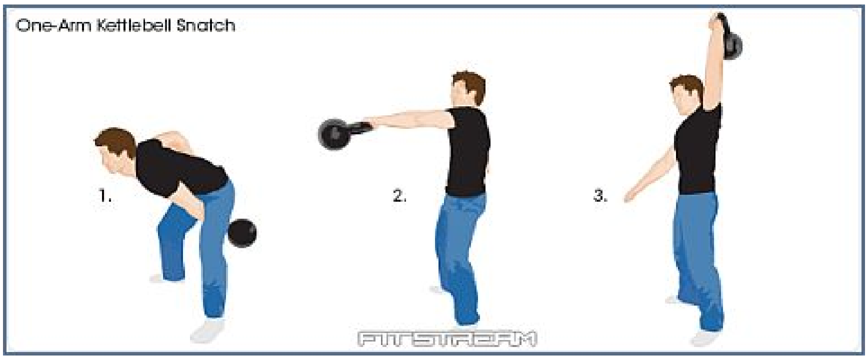
1. Seven healthy males recruited from a university population performed exercises with a kettlebell (one-armed swings, swings with Kime and snatches with a 16 kg kettlebell). They were excluded from the study if they reported any previous or current LBP. Five of these participants were selected to carry the kettle bell and be measured while performing carries in the racked position (bell on the backside of the forearm) and in the bottoms-up position. All lifts and carries were performed in the right hand (which explains the side-to-side differences in the results).
2. The second part of the study was a single case study performed on a world renowned kettlebell master, Pavel Tsatsouline.

Exercise Description

The kettlebell swing: Each participant started their kettlebell swing from the neutral-spine squat position, with the bell in their right hand. The subject was cued to begin the swing through simultaneously extending the hips, knees and ankles. This forcible extension drove the bell superiorly in the saggital plane to chest level. Once this level was reached, the bell was lowered to the starting position.

Kettlebell swing with Kime: This exercise was performed in the same manner as the kettlebell swing, only with the addition of a pulse-like abdominal contraction once the bell reached chest height.

Kettlebell swing-to-snatch**:** This swing was initiated in the neutral-spine squat position. The subjects were required to produce an extension moment about the hips, knees and ankles sufficient enough to swing the kettlebell into a supported position overhead. This was held for 2 seconds



Procedures
Carrying: 5 of the 7 subjects were asked to carry the kettlebell in either the racked or bottoms-up style positions. While in the bottoms-up position, the bell was held at shoulder height with the elbow flexed to 90°. The racked position was executed with the bell resting on the posterior forearm at shoulder height with the fist close to the chin.

16-channel EMG recordings were collected by placing pairs of electrodes over the right and left rectus abdominus, right and left external oblique, right and left internal oblique, right and left latissimus dorsi, the right and left lumbar paraspinal muscles, right and left gluteus medius, right and left gluteus maximus and the right rectus femoris.

Maximal voluntary contraction (MVC) of each muscle was measured. Peak muscle activation for each muscle was expressed as a percentage of MVC. Additionally, the average shear load of L4 on L5 and compressive loads at L4/L5 were calculated for each kettlebell swing type.

<u>STUDY STRENGTHS / WEAKNESSES</u>

Strengths

- This is the first study of its kind, which actually measured muscular activation and posterior shear through vertebral segments.

Weaknesses

- The authors stated that they did not control for individual levels of fitness, which could have influenced the results.
- Small sample size

Additional References

1. McGill, SM. Low back disorders: Evidence-based prevention and Rehabilitation. Champaign IL: Human Kinetics, 2007.
2. McGill, SM. Ultimate back fitness and performance. Waterloo, ON: Backfitpro Inc., 2009.