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A Comparison of Muscle Activity Depending on Shoulder Joint Flexion Angle When Conducting Kettle Bell Swing

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Abstract

Background/Objectives: The kettle bell exercise is effective in improving the strength and physical strength of the whole body as a popular exercise for modern people. The purpose of this study was to compare the muscle activity of Biceps femoris, Vastus medialis oblique, Erector spine and Anterior deltoid depending on shoulder joint flexion angle when conducting kettle bell swing.

Method/Statistical Analysis: The kettle bell exercise is effective in improving the strength and physical strength of the whole body as a popular exercise for modern people. The purpose of this study was to compare the muscle activity of Biceps femoris, Vastus medialis oblique, Erector spine and Anterior deltoid depending on shoulder joint A total of 30 healthy men and women who agreed to participate in the study were the subjects. All of the kettle bell swing starting positions were conducting with flexion knee about 50° and the whole body. The shoulder flexion angle was set 90°, 140°, 180° and the end position was the same as the starting position. For comparison of the muscle activity depending on shoulder joint angle, One-way Repeated ANOVA was used and Bonferroni method for post-test.

Findings: Biceps femoris showed significant differences at all degrees($P<.05$). And vastus medialis oblique and anterior deltoid showed significant difference at 90°, 140°, 180°. And there was no significant difference between 140° and 180° ($p>.05$). There was no significant difference in the spinal erector muscle ($p>.05$).

Improvements/Applications: Therefore the muscle activity degree for each muscle was clearly different depending on the shoulder angle.

Keywords: *Kettle bell, kettle bell swing, muscle activity, exercise, peak value.*

Introduction

In the modern industrialized society, physical labor work has become rare due to technological advance and sedentary style of living has spread widely[1]. Therefore the average amount of daily physical activity in humans has decreased dramatically over the past century[1]. However, regular physical activity is essential for the prevention of health problems such as chronic diseases. It is known that physical exercise is beneficial to the body in various ways[1]. People are getting more recognized on how health care impacts on the quality of life. The World Health Organization defined the health as "a dynamic and complete state of physical, mental, social, and spiritual well-being and absence of disease." It means absence of physical anomalies and active physical activity. Physical activity does a positive influence on physical health and is an essential factor for health promotion as it is also effective in mental health. Especially kettle bell training has been very popular by the strength and conditioning community in recent years. Fitness experts and coaches often suggest that kettle bell training is an excellent way to develop explosive strength[2]. Manocchia et al study stated that the kettle bell is an effective way to improve physical

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fitness and has the effects of increased body strength. And the kettle bell is not only limited to athletes' sport training[3]. Basically, the kettle bell swing is technically a simple and full-body exercise[4]. Also the kettle bell exercise reduces neck and shoulder pain and back pain, improves muscle strength, hips and waist, pelvic muscle strength and endurance[5-6]. Among the studies related to the kettle bell exercise, studies on the swing type have been conducted for comparison of peak force and muscle activity[7-8]. A study on peak values in three swings of shoulder height, overhead, and Indian club swing did not measure muscle activity even though the shoulder joint flexion or abduction angle was different for each type[7]. In the study comparing the muscle activity of each type; kettle bell arm swing (Swing), arm swing style snatch (Snatch), arm clean (Clean) were not classified according to the shoulder joint flexion angle[8]. Studies on observation of the muscle activity of the whole body including the upper limb and the lower limb according to arm lifting angle with flexion shoulder are lacking. Thus, this study is to investigate the most effective type of kettle bell swing by comparing the muscle activity of various parts according to the shoulder joint flexion angle.

Method

This study subjects were 30 healthy male and female adults in S university located in Asan, Chungnam. They had no medical history or visiting for shoulder, knee or back pain. All the subjects voluntarily participated through advertisement invitation and were finally selected after confirming that they meet the following criteria. The subjects should have meet the following criteria. 1) Those who did not visit the hospital due to shoulder, knee, and back pain 2) Those who have no pain or discomfort when moving shoulder, knee or waist 3) Those who did not get surgery on shoulder, knee or waist. 4) Those who have no inflammatory, degenerative joint or connective tissue disease 5) Those who have musculoskeletal disease in shoulder, knee, or waist. The physical characteristics of the subjects were as follows. In this study, a total of 30 subjects (15 men and 15 women) were randomly selected and the muscle activity of Biceps femoris, Vastus medialis oblique, Erector spine and Anterior deltoid when conducting kettle bell swing depending on shoulder joint flexion 90°, 140° and 180°. The weight of kettle bell was 8kg for male and 4kg for female. For the starting position, they bent the hips and knees slightly at degree 50°. They left up kettle bell at shoulder flexion angle and the shoulder flexion angle was 90°, 140° and 180°. After 3 times of shoulder joint flexion angle and 3 minutes of rest time, they moved on the next experiment. The end position was the same as the starting position.

And the peak value of muscle activity of each muscle was found when conducting kettle bell exercise. In order to examine the muscle activity of Biceps femoris, Vastus medialis oblique, Erector spine and Anterior deltoid, EMG (Zero WIRE EMG, EMG OQUS100, Italy, 2009) was used. The collected EMG analog signals from 4 channels were converted to digital signals by MP150 system and the study is analyzed using EMG software myoresearch 1.06.44 software. The sampling rate of EMG signal was set to 1,000Hz and the subsequently smoothed by a RMS filter of 50ms. In order to examine the muscle activity of the subjects' shoulder joint flexion depending on 90˚, 140˚, 180˚ when conducting kettle bell swing, surface EMG was attached on each muscle. The attachment part is as follows. 1) The EMG attachment part of Biceps femoris is 15cm below the ischial tuberosity. 2) The EMG attachment part of Vastus medialis oblique is attached to the inner oblique direction of the center line from 2cm above the knee bone. 3) The EMG attachment site of Erector spine is attached on the outside of neural spine 3cm far from lumbar vertebrae number 4 and 5. 4) The EMG attachment part of Anterior deltoid is attached 3.5cm below the front of the acromion. For precise measurement, electromyography was performed to clean the attachment part before attaching surface electrode adherence. It minimized skin resistance and wiped the electrode attachment part by alcohol cotton. In order to analyze the data of this study, SPSS 22.0 version program was used. And one-way repeated ANOVA was used to compare the muscle activity depending on shoulder joint flexion angle and post-test was conducted with Bonferroni. The statistical significance level of this study was set at $p<.05$.

Result

The EMG signals of the muscles was measured depending on 90°, 140°, 180° flexion when conducting kettle bell swing. As a result, there was significant difference between the muscle activity of lower limbs muscle and deltoid muscle depending on flexion angle ($p<.05$). The peak value of Biceps femoris was 284.93±133.65% when flexion shoulder joint at 90° and 404.66±143.23% when flexion shoulder joint 140°. And 356.80±164.48% when flexion shoulder joint 180°. All flexion shoulder joint showed significant differences (p<.05). The peak value of vastus medialis oblique was 619.47±130.26% when flexion shoulder joint at 90°, 680.45±120.65% when flexion shoulder joint at 140° and 718.77±144.34% when flexion shoulder joint at 180°. All flexion shoulder joint showed significant differences (p<.05). However, flexion angle 140° and 180° had no significant differences(p>.05). The peak value of anterior fiber of deltoid muscle was 507.15±206.03% when flexion shoulder joint at 90°, 596.91±206.46% when flexion shoulder joint at 140°, 623.01±190.94% when flexion shoulder joint at 180°. All flexion shoulder joint showed significant differences (p<.05). However, flexion angle 140° and 180° had no significant differences (p>.05). The peak value of the erector spine was 389.75±204.35% when flexion shoulder joint at 90°, 428.51±181.92% when flexion shoulder joint at 140° and 446.59±148.56% when flexion shoulder joint at 180°. All flexion shoulder joint showed no significant differences (p<.05). [Table 1] [Figure 1].

Table 1. EMG of muscles depending on shoulder joint flexion 90°, 140° and 180° when conducting kettle bell swing

	90°	140°	180°	F
Biceps femoris	284.93±133.65	303.66±143.23	356.80±164.48	6.42*
Vastus medialis oblique	619.47±130.26	680.45±120.65	718.77±144.34	12.81*
Erector spine	389.75±204.35	428.51±181.91	446.59±148.56	1.40
Anterior deltoid	507.15±206.03	596.91±206.46	623.01±190.94	11.79*

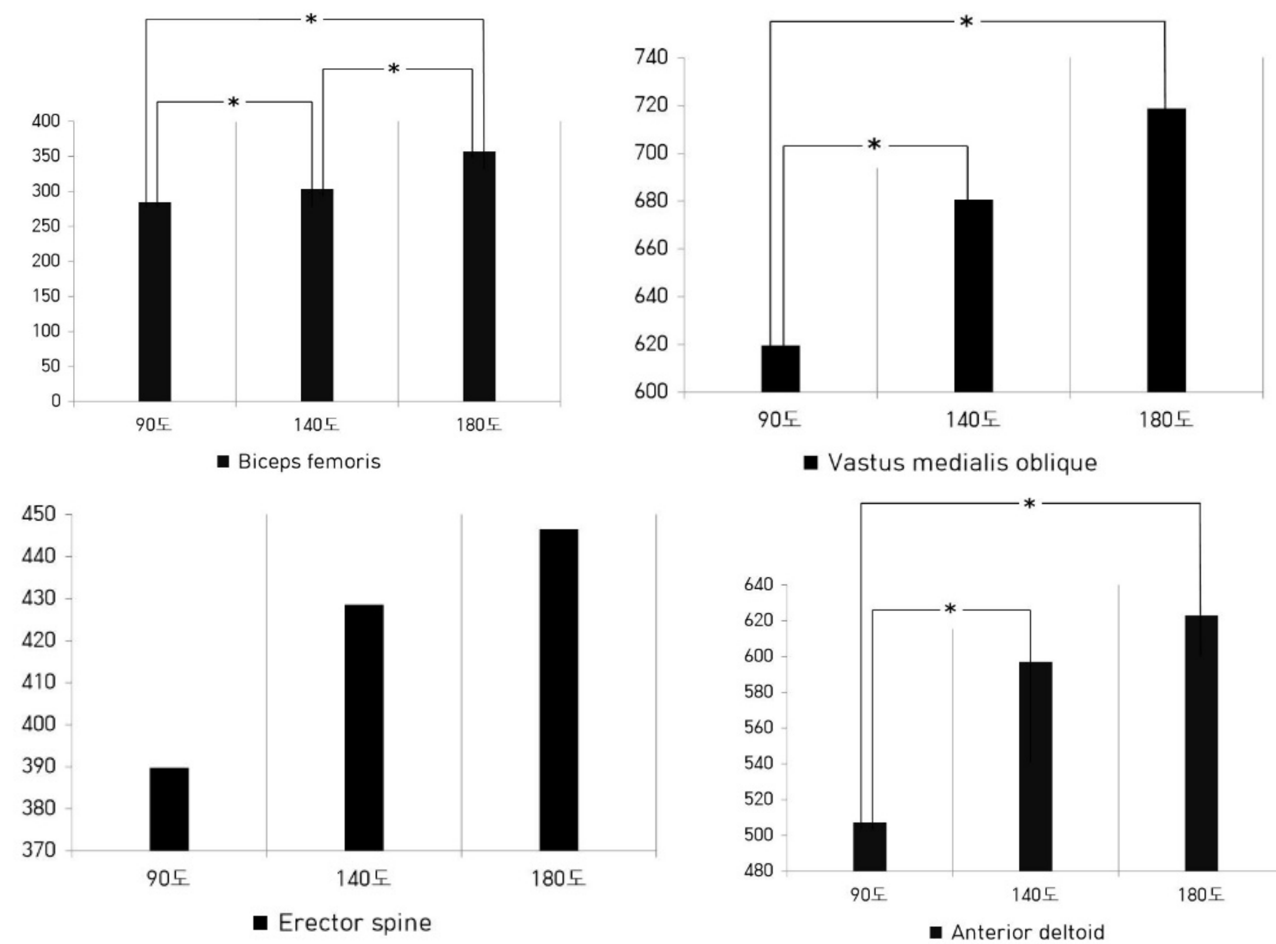

Figure 1. Comparison of muscle activity depending on shoulder joint flexion angle

Discussion

This study compared the muscle activity of various muscles when conducting kettle bell swing depending on the change of shoulder joint flexion angle. As a result, there was a statistically significant difference in Biceps femoris, Vastus medialis oblique, Erector spine and Anterior deltoid depending on shoulder joint flexion angle. In biceps femoris, as shoulder joint increased, the signal intensity of the EMG signal was higher. And vastus medialis oblique and anterior deltoid showed higher muscle activity at flexion angle 140° and 180° rather 90°. There was no significant difference between 140° and 180° flexion of vastus medialis oblique and anterior deltoid. The study on peak values according to three swing method of Bullock et al suggested that shoulder height kettle bell swing; SKS, overhead kettle bell swing; OKS, indian club swing; ICS resulted that SKS was shorter in cycle than OKS and vertical impacts were relatively low[7]. And this study measured foot flexion of the ankle joint, extension of the knee joint and extension of the hip joint using Visual 3D (C-Motion, Bethesda, Maryland, USA) when conducting kettle bell exercise. As a result, SKS and OKS showed greater maximum force in foot flexion of the ankle joint and extension of the hip joint compared to ICS. And vertical ground reaction force was also greater[7]. In this study, the shoulder joint flexion angle was divided into 90°, 140° and 180° to conduct kettle bell swing. The study was conducted to find the effects of kettle bell swing depending on shoulder joint flexion size. Bullock's et al similarly studied the swing type by dividing into three. However OKS and ICS was similar in terms of flexion shoulder maximumly when considering kettle bell swing and focusing on shoulder joint movement. Therefore there was lack of examining muscle activity depending on flexion angle. The kettle bell exercise is for whole body but this study was insufficient to examine various muscles depending on swing type by measuring the peak value of the lower part of muscles. For this reason, this experiment was conducted. The study above showed that the cycle time of OKS was 34% longer than that SKS and ICS. This study also showed that the operation time of the swing with shoulder joint flexion at 180° was the longest. And the peak value of OKS was higher than that SKS when the hip joint was opened. This study showed that the muscle activity of biceps femoris which opens the hip joint was higher at 140° than 90° and was also higher at 180° than 140°. The results were similar to the previous studies. According to Studies by McGill and Marshall said healthy subjects did kettle bell swing with both hands and resulted in an activation of MVIC (maximal voluntary isometric contraction) of 70.1%±23.6%[5]. This was within 50% to 60% of MVIC which is proposed to be stimulating enough to muscle strengthening[9-11]. This suggests that the swing method with both hands is more effective than the one-handed swing. Therefore, this study was designed as a swing method with both hands. And the most effective and responsible reaction was measured by dividing shoulder flexion angle into three stages rather than simply focusing on swing with both hands. Lyons et al measured the muscle activity of biceps femoris, anterior deltoid and posterior deltoid, spinal erector muscle, vastus lateralis, external oblique abdominal muscle and gluteus maximus muscle[8]. In particular, the spinal erector muscle showed greater muscle activity in the swing type than the Snatch type[8]. Since the Kettle bell exercise method of this study was also the swing, it measured the EMG of the spinal erector muscle when conducting kettle bell swing. However, there was no difference in the effect according to the height of the shoulder joint because it was the intervention method using the similar type. In the hip joint exercise, the muscle activity of biceps femoris was also measured when conducting the kettle bell swing. As he subject of this study was the result of muscle activity depending on shoulder joint flexion angle, it measured the anterior fiber of deltoid muscle and the EMG signal of biceps femoris which is one of the important factors in the kettle bell swing exercise and stretches knee. Especially, vastus medialis obliquethe is the weakest physiologically as an inner support surface and muscle weakness appears first[12]. The weakening of vastus medialis oblique breaks the balance of the muscular development of biceps femoris and responds outsider support surface and decreases inner power when stretching knee joint. Therefore it can cause PFPS (Patella Femoral Pain Syndrome) and subluxation of knee bone. Since the role of vastus medialis oblique is important, the study examined which position causes the highest muscle activity when conducting the kettle bell swing. As a result, it is considered that vastus medialis oblique increases momentum in range of shoulder joint angle over 90 degree and causes the higher muscle activity. Therefore, it can be applied effectively to patients with PFPS. The limitation of this study is that subjects were all healthy 20s' generation people but not various ages or professionals. Therefore it is difficult to generalize the result of the study. And the subjects' fat mass, body fat percentage, muscle mass, and normal exercise status were not taken into considerations. The experiment group was divided into each gender without considering weight differences. Because the subjects exercised kettle bell of the same weight, it caused the limitation. It would be possible to suggest better results if the limitation of this study is to be removed in future studies.

Conclusion

The results of this study showed significant difference in the muscle activity of biceps femoris, vastus medialis oblique, erector spine and anterior deltoid but no significant difference in the erector spine. Therefore the muscle activity degree for each muscle was clearly different depending on the shoulder angle. The kettle bell exercise of various shoulders joint is recommended on basis of the results of the study.

Ethical Clearance: This study was approved by the Institutional Review Board (IRB) of Sunmoon University SM-201805-043-2.

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Conflict of Interest: Nil

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