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ORIGINAL RESEARCH

MUSCLE ACTIVATION OF THE TORSO DURING THE MODIFIED RAZOR CURL HAMSTRING EXERCISE

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ABSTRACT

Purpose/Background: The RAZOR curl has been introduced as a hamstring exercise. However, modifications to the exercise have been developed which are proposed to utilize some of the muscles of the lumbo-pelvic-hip complex. Thus, it was the purpose of this study to quantitatively examine the modified RAZOR curl using surface electromyography (sEMG), as an exercise that may recruit the trunk muscles of the lumbo-pelvic-hip complex.

Methods: Twenty-eight active male and female graduate students (24.2 ± 1.3 years; 174.8 ± 9.9 cm; 74.9 ± 14.9 kg), consented to participate. Dependent variables were muscle activation of trunk musculature (dominant side gluteus medius, gluteus maximus, multifidus, longissimus, lower rectus abdominis, upper rectus abdominis, external obliques) reported as percent of maximum voluntary isometric contraction (%MVIC) during the exercise while the independent variable was the muscle selected.

Results: The multifidus and longissimus demonstrated moderately strong activation (35-50%MVIC) while the upper rectus abdominis demonstrated strong activation (20-35%MVIC) and the gluteus medius, gluteus maximus, lower rectus abdominis, and external obliques had minimal activation.

Conclusions: These findings allow the practitioner to utilize an exercise that provides a functional training stimulus that activates not only the hamstrings but also some musculature of the trunk muscles of the lumbopelvic-hip complex at strong to moderately strong levels.

Level of Evidence: 5

Key Words: core control; core stabilization; functional exercises; sEMG

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All testing protocols implemented in the current study were approved by the University of Arkansas Institutional Review Board.

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INTRODUCTION

Neuromuscular factors such as trunk and hamstring control and efficiency have been associated with both injury and injury prevention.[1-5] Biomechanically, the body can be depicted as a kinetic link model or a kinetic chain. Dynamic stability of the kinetic chain that includes the lower extremity and trunk is based on the neuromuscular control of the lumbopelvic-hip complex.[3,6,7] The lumbopelvic-hip complex is composed of the hip, pelvis, and trunk segments, including the musculature either originating from or attaching on the hip, pelvis, and trunk. Based on the body's natural motor patterns of the neuromuscular system, the musculature of the trunk activates prior to the musculature of the lower extremity.[2] In addition, dynamic stability of the trunk has been postulated to provide a stable base of support for functional movements of the upper and lower extremities,[2] just as inefficient control of the trunk has been associated with hamstring injuries[8] and knee pathologies spanning from patellar tendonitis to anterior cruciate ligament injuries.[5]

When performing sports specific movements, the musculature of the trunk must function dynamically in multiple planes. Trunk muscle control and or stability demands escalate as movements become multiplanar and increase in intensity.[9] As movements become more dynamic or sport specific, the ability to make the postural corrections becomes more difficult because of the multiple planes involved, speed and complexity of the movement, and the required decrease in reaction time. There have been many proposed exercises that have targeted musculature of the lumbopelvic-hip complex due to the need for torso control and stability in dynamic movements.[10-16]

Recently, Oliver and Dougherty[17] described a functional approach to hamstring training with the RAZOR curl, an exercise resembling the Russian hamstring curl.[18] They introduced this exercise to the strength and conditioning arena in an attempt to train the hamstrings in a more sport specific position of hip flexion allowing for a more optimal and forceful contraction of the hamstrings at the knee.[17] The premise of the development of the RAZOR curl was to position the hamstrings in a lengthened state at their proximal end to allow for more force demands at their distal end. In attempt to place the proximal hamstrings in a lengthened position, the hip must be flexed prior to the knee flexion contraction. Thus, when training athletes to maximize hamstring strength and endurance of the knee flexion function, it is important to have the hip flexed in order to elongate the proximal hamstring. Essentially, this exercise combines the hamstring benefits of the traditional Russian hamstring curl, by using a position that provides a shorter body lever. It also may bring the benefits of the traditional roman chair back extension exercise, using a bent knee position, which provides a shorter body lever to the low back. The shorter body lever position serves mainly to reduce low back load stresses, but may also provide a way to train the hamstrings in sport-specific position that incorporates both body position and closed kinetic chain motion. The RAZOR curl has been shown to exhibit adequate hamstring and gluteal activation as compared to the traditional prone hamstring curl[19] and has subsequently been described as a functional exercise for hamstring training.[17] However, there have been some questions about the RAZOR curl and the equipment needed for its performance. As introduced, the RAZOR curl was performed on a back extension machine. With the potential cost and lack of availability of the equipment, many have found ways to make modifications to the exercise by performing it on a flat sit-up bench. The modification allows the feet to be anchored on a sit-up bench while kneeling, knees flexed to 110 degrees and hip extended [Figure 1]. The individual then moves into the position of 90 degrees of knee and 90 degrees hip flexion [Figure 2]. Once in 90 degrees of knee and hip flexion, the individual returns to the starting position.

Figure 1. *Knees flexed 110 degrees and hip extended.*

Figure 2. *Knees and hips at 90 degrees of flexion.*

The introduction of the RAZOR curl and even the modified RAZOR curl has proved to be clinically applicable, since it is anecdotally easier to perform than the traditional Russian hamstring curl. More importantly, there is a great need to address torso and hamstring training among athletes, in particular, female athletes in an effort to prevent or mitigate knee injury risk.[20] Because several authors describe the need for neuromuscular control of the torso and hamstring for lower extremity injury prevention,[5,17,19] the investigators wanted to examine the modified RAZOR curl in order to determine the trunk muscle activation associated with this exercise. Although the RAZOR curl activates the hamstring and gluteal muscle groups, the modified version may also influence other muscles that are part of the lumbopelvic-hip complex component. Oliver and Daugherty[17] did not examine trunk muscle activation during the performance of the original investigation of the RAZOR hamstring exercise. As a means of hamstring training, the RAZOR curl is often implemented not only in knee rehabilitation protocols but also in injury prevention exercise regimens such as neuromuscular training for landing strategies. Dougherty and Oliver[17] proposed that the RAZOR curl may be useful for injury prevention as compared to traditional hamstring strengthening due to the potential incorporation of some of the musculature of the lumbopelvic-hip complex, which therefore may allow it to be useful for injury prevention as compared to traditional hamstring strengthening. Therefore, it was the purpose of this study to quantitatively examine the modified RAZOR curl using surface electromyography (sEMG), as an exercise that may recruit the trunk muscles of the lumbopelvic-hip complex. The authors hypothesized that when performing the modified RAZOR curl, musculature of the lumbopelvic-hip complex would exhibit moderate activation similar to previously examined core exercises.[12]

METHODS

Muscle activations were recorded through normalized surface electromyographic [sEMG] data as an average percent of the participant's maximum voluntary isometric contraction [MVIC] while performing the modified RAZOR curl. The lumbopelvic-hip complex muscles targeted have been previously examined by sEMG[15,17,19,21] and were dominant side gluteus maximus, gluteus medius, multifidus, longissimus, upper rectus abdominis, lower rectus abdominis, and external obliques.

Twenty-eight active male and female graduate students [24.2±1.3 years; 174.8±9.9 cm; 74.9±14.9 kg] consented to participate [Table 1]. Active, for the purpose of this research, was defined as participating in 30 minutes or more of strength and conditioning exercise three to five days a week without history of back or lower extremity injury in the past six months. In addition all participants were familiar with the modified RAZOR curl and implemented it into their weekly training. The modified RAZOR curl was

Table 1. *Participant demographics.*

Muscle	%MVIC Mean	SD
Gluteus Medius	13.8	7.6
Gluteus Maximus	11.8	7.0
Multifidus	35.9	21.7
Longissimus	38.0	40.8
Lower Abdomen	6.1	6.8
Upper Abdomen	24.4	27.4
External Obliques	17.7	17.4

defined as the previously described exercises utilizing a sit-up bench [Figure 1], progressing to 90 degrees of knee and 90 degrees of hip flexion [Figure 2], and then returning to the starting position. The University of Arkansas Institutional Review Board approved all testing protocols implemented in the current study and prior to any participation the procedure, risks, and benefits of the study were explained to all participants. Informed consent was obtained from each of the participants, and the rights of the participants were protected according to the guidelines of the University's Institutional Review Board.

Participants reported to the athletic training education laboratory classroom prior to engaging in any form of physical activity that day. Locations of dominant side gluteus medius, gluteus maximus, multifidus, longissimus, upper rectus abdominis, lower rectus abdominis, and external obliques were identified by a certified athletic trainer through palpation assessment as defined by Kendall et al.[22] Dominant side was chosen by the hand that the participant chose to hold a pencil. The skin surfaces overlying the muscle bellies prepped according to previously established protocols.[15,17,19,21,23] After the area was clean, adhesive 3M Red-Dot [3M, St. Paul, MN] bipolar surface electrodes were attached on the muscle bellies and positioned parallel to the muscle fibers using the techniques described by Basmajian and Deluca[24] with an inter-electrode distance of 25 millimeters.[15,17,19,21,25]

Surface EMG data were recorded via a Noraxon Myopac 1400L 8-channel amplifier [Noraxon USA, Inc., Scottsdale, AZ]. All sEMG signals were full wave rectified and root mean squared at 100ms. Throughout all data collection, data were sampled at a rate of 1000Hz and filtered with standard band-pass filtering. Following electrode placement, two manual muscle tests [MMTs] of five seconds each were performed, by a certified athletic trainer for each muscle utilizing the techniques of Kendall.[22] The MMTs were used to identify the MVIC for each muscle. The multifidus was tested with the participant prone, arms crossed over chest and attempting to perform back extension and rotation to the opposite side while the investigator resisted the motion. Obliques were tested with the participant supine, arms crossed over chest and the subject positioned in 45° of trunk flexion. The participant the attempted trunk flexion and rotation to the opposite side while the investigator stabilized the legs and resisted trunk flexion and rotation. The upper rectus abdominis and lower rectus abdominis MMTs were both performed with participant in a supine position, arms crossed over chest, legs in 75° of hip flexion, and pelvis in neutral position. The lower rectus was tested by the investigator pushing the participant into hip extension, while the upper rectus was tested as the patient tried to perform trunk flexion with the investigator providing resistance. The MVIC for each muscle served as the baseline reading to which the participant's sEMG activity would be compared.

Following the MMTs, the investigators instructed the participants on the proper technique for the modified RAZOR curl exercise. Participants viewed repeated demonstrations and had unlimited time to practice, with no participant performing more than 5 repetitions. The average time for the participants to get correct performance was three repetitions, since all participants were familiar with performing the RAZOR curl. During their practice trials they were given verbal feedback on proper technique. Once the participant felt comfortable with the technique, they performed three trials of the modified RAZOR curl, as described previously. Participants performed three consecutive trials with no rest period between trials. During each trial, participants were given verbal cues and feedback. Participants were informed when they reached 90 degrees of knee and hip flexion as observed by the investigators. If the participant did not achieve full range of motion, the trial was repeated. The trials in which the participant achieved full range of motion were recorded. All data were analyzed and normalized as the mean percent of each participant's MVIC over three trials.

Data Analysis

Descriptive statistics were used to describe muscle activation of the dominant side gluteus maximus, gluteus medius, multifidus, longissimus, upper rectus abdominis, lower rectus abdominis, and external obliques while preforming the modified RAZOR curl in terms of means and standard deviations, using GraphPad Prism 5.0 [GraphPad Software, Inc., San Diego, CA] and to determine each muscle's mean percent of MVIC. In addition, percent MVICs were categorized as minimal activation for 0-20% MVIC, moderate activation for 20-35% MVIC, moderately strong activation at 35-50% MVIC, and greater than

50% MVIC was considered significantly high activation.[26] Subsequent analyses were conducted using a two-way analysis of variance [ANOVA] using Bonferroni post hoc analyses. The level of significance was set a priori at $p < 0.05$.

RESULTS

The modified RAZOR curl hamstring exercise resulted minimal activation of the gluteus medius, gluteus maximus, lower rectus abdominis, and external obliques, while the upper abdominis displayed moderate activity, and the multifidus and longissimus revealed moderately strong activity. Percent of MVICs expressed as means and standard deviations are presented in Table 2.

DISCUSSION

Previously, research has described the RAZOR curl as being a functional hamstring exercise.[17] As one performs the RAZOR curl there is an element of lumbopelvic-hip complex muscle activation. This study examined muscle activation of selected muscles within the lumbopelvic-hip complex during the modified RAZOR curl. The results revealed that of all the muscles examined, the multifidus and longissimus had the greatest activation, which can be described as moderately strong when expressed as %MVIC. In an attempt to compare the current study's findings to other popular exercises that have been suggested to address similar musculature of the lumbopelvic-hip complex, %MVICs reported from the RAZOR curl were compared to %MVICs previously reported from another study [Table 3].[12] When focusing on muscle activation of the lumbopelvic-hip complex, the longissimus and multifidus were isolated from each study. Figure 3 represents the %MVIC reported for both muscles during the modified RAZOR curl, side-bridge, unilateral bridge, prone bridge, and lunge as derived from the present study and the previous one. The modified RAZOR curl produced similar muscle activations in the longissimus (38%MVIC) as the side-bridge (40%MVIC) and unilateral bridge (40%MVIC) exercises and activations of the multifidus during the modified RAZOR curl (35.9%MVIC) were similar to those produced during the side-bridge (42%MVIC), unilateral bridge (44%MVIC), and lunge exercises (25%MVIC).

The current study implemented a modified RAZOR curl set up while the participants performed the original RAZOR hamstring exercise. The muscle activation of the gluteus maximus and medius were the only muscles analyzed in this study that were previously examined in the original RAZOR curl study. The activations of both the gluteus medius and gluteus maximus exhibited lower percent of MVIC as compared to the values previously reported (100 and 66%MVIC respectively).[19] It was postulated by the investigators that the change in positioning of the torso with the modified RAZOR curl allowed for the decreased gluteal activation.

The importance of these findings allows the practitioner to utilize the modified RAZOR curl not only as a hamstring exercise but also as an adjunct to lumbopelvic training. The main difference in the modified RAZOR curl is that from the knee and hip position of 90 degrees of flexion, the individual then extends their hip and knee in the ending position, versus the original RAZOR curl the individual stays in a position of 90 degrees of knee and hip flexion. In this position, the lumbar extensors are able to provide support due to the aid of the posterior leg muscles. However, with the hip and knee remaining flexed, the lumbar extensors may be challenged in their attempt to promote

Table 2. *Electromyographic data normalized and expressed as mean percent of MVIC while performing the modified RAZOR curl.*

Muscle	%MVIC Mean	SD
Gluteus Medius	13.8	7.6
Gluteus Maximus	11.8	7.0
Multifidus	35.9	21.7
Longissimus	38.0	40.8
Lower Abdomen	6.1	6.8
Upper Abdomen	24.4	27.4
External Obliques	17.7	17.4

Table 3. *Electromyographic data normalized and expressed as mean percent of MVIC of different core exercises.*		
Muscle	%MVIC Mean	SD
SIDE BRIDGE		
Gluteus Medius	74	30
Gluteus Maximus	21	16
Multifidus	42	24
Longissimus	40	17
Abdomen	34	13
External Obliques	69	26
UNILATERAL BRIDGE		
Gluteus Medius	46	24
Gluteus Maximus	40	20
Multifidus	44	18
Longissimus	40	16
Abdomen	16	13
External Obliques	23	16
PRONE BRIDGE		
Gluteus Medius	27	11
Gluteus Maximus	9	7
Multifidus	5	4
Longissimus	6	4
Abdomen	43	21
External Obliques	47	21
LUNGE		
Gluteus Medius	29	12
Gluteus Maximus	36	17
Multifidus	25	11
Longissimus	17	8
Abdomen	7	5
External Obliques	17	11
All data reported by Ekstorm et al. 2007		

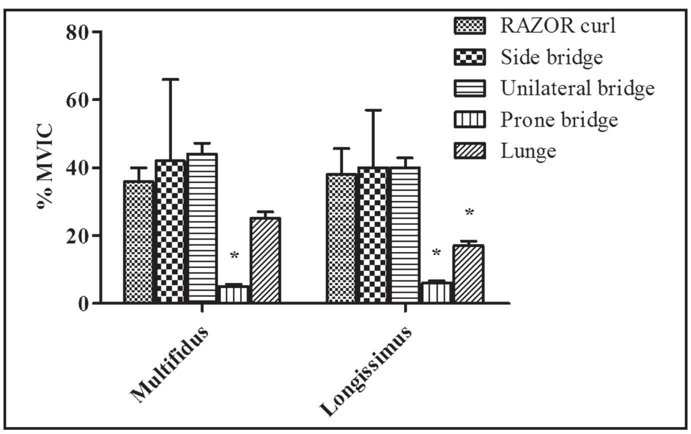

Figure 3. *Percent of MVIC significantly different from the %MVIC produced using the RAZOR curl exercise within the corresponding muscle ($p < 0.05$).*

postural awareness and maintance of a neutral lumbar curve.[27] The neutral lumbar curve, along with the demands of torso control, during the modified RAZOR curl may address low back muscle endurance and motor control of the lumbar extensors, although neither of these constructs were examined in the current study. Both are critical aspects of trunk extensor training that may serve to not only reduce low back injury risk[28,29] but also decrease risk of knee injury,[5,8] and should be examined in future research.

Muscle activations recorded in the current study resulted in similar percent of MVIC levels for lumbopelvic-hip musculature when compared to a previous study that examined similar muscle activations during other common core exercises. The current study revealed a high level of muscle activity in the longissimus and multifidus. This is significant because the multifidi are deep spinal muscles that stabilize against spinal rotation and forward flexion as well as contribute to dynamic stability of the sacroiliac joint.[30] The longissimus muscle group produces a high extensor moment with minimal compressive penalty to the spine due to architectural alignment being directly under the lumbodorsal fascia of the spine. This produces an optimal line of pull along the spine that gives it the greatest possible moment arm.[31] It is important to recognize that the optimal stabilization of the torso occurs when the relevant core muscles, such as the transverse abdominis and multifidus, fire synergistically to create ideal dynamic stability via coordinated motor control and muscle contraction synchrony.[32]

The results of the current study must be interpreted with caution when determining if strengthening of the trunk musculature could occur during performance of this exercise. Although the multifidus and longissimus demonstrated moderately strong activity and the greatest of the muscles examined, the level of activity produced by the modified RAZOR exercise may not be sufficient to provide a muscular strengthening stimulus. Previous authors have reported that muscular strengthening requires 50-60%MVIC.[33]

Essentially, it is the coordination and neuromuscular control of both the longissimus and multifidus along with the rectus abdominis and obliques that may enhance lumbopelvic-hip stability.[31] The rectus abdominis and obliques are prime movers for trunk flexion and rotation. The oblique muscle group is activated in direction specific patterns in effort to support the pelvis prior to limb movement.[2,34] Although the multifidus and longissimus have different attachment sites and functions, both have a muscle fiber arrangement that serves to protect the back against anterior shear forces commonly seen in a forward flexed posture.[30,31] Another important component of these two muscles is that they also serve to function eccentrically in order to control descent of the trunk during forward bending and isometrically control the position of the lower thorax in relation to the pelvis during functional movements.[30]

The fact that all muscles of the trunk examined [upper and lower abdominis, external obliques, multifidus, longissimus, gluteus medius, and gluteus maximus] were active, ranging from minimal to moderately strong, does reveal that the trunk prime movers and stabilizers are targeted when performing the modified RAZOR curl. The current findings reinforce the importance of not only posterior leg and torso training, but also help offer an exercise that may be functional, yet is still practical.[17] Therefore, the modified RAZOR curl is a practical exercise that can be easily adapted and more importantly, provide moderate to moderately strong recruitment to selected musculature of the lumbopelvic-hip complex. When combined with earlier research, it appears that this exercise can recruit both lumbo-pelvic muscles and the hamstrings.

LIMITATIONS

The use of sEMG on the multifidus muscle group could be regarded as a limitation. The multifidus muscle group is complex, in that there are superficial and deep fibers. However, it is difficult to differentiate between them both anatomically and biomechanically.[32,35] It has been proposed, based on the anatomy of the superficial multifidius [those examined in the current study], that this muscle provides both efficient control of lumbar extension as well as spinal orientation control.[36] A second limitation was the use of sEMG. Although electrode placement was in accordance to Kasman et al,[23] sEMG does have a limitation of cross-talk between electrodes. The nature of sEMG often allows for cross talk among muscles that are close in proximity. In addition, it has been noted that when trying to recorded sEMG of the multifidus, the longissimus muscle activity is often recorded instead. When keeping with the sEMG protocol, it is recommended that if it is the multifidius that are of interest, then further investigation of the longissimus should also be included in attempt to differentiate between the two muscle activations. In addition, the deep fibers of the multifidus should be addressed by indwelling fine wire electrodes versus surface electrodes.

CONCLUSION

Neuromuscular function of the lumbopelvic-hip complex can be considered an important element in core and resultant lower body movement control and efficiency. There is great need for intervention among athletes participating in power sports due to the increased incidence of low back and knee injuries. Neuromuscular training can significantly cut down on the number of low back and knee injuries among athletes, especially with female athletes.[20,29] The present study introduced and examined the muscular recruitment during the modified RAZOR curl using a sit-up bench. The findings of the current study may provide practitioners a new time-efficient exercise for recruiting muscles important to core and hip stability.

Furthermore, the beneficial effects of the RAZOR curl for activating musculature of the lumbopelvic-hip complex were described. Therefore, the modified RAZOR curl is a practical and functional exercise that can be easily adopted with various equipment and provide an opportunity to train the hamstrings in a functional manner while providing a stability challenge to important torso musculature.

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