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Muscle Activation Pattern During Isometric Ab Wheel Rollout Exercise in Different Shoulder Angle-Positions

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OBJECTIVE: To investigate muscle activation of the shoulder extensors and trunk stabilizers by surface electromyography (sEMG) activity during the isometric Ab Wheel Rollout exercise in different shoulder joint positions.
METHOD: We recruited 8 young, healthy, resistance trained men (age: 25 ± 3 years, height: 178 ± 5 cm, and total body mass: 81 ± 2 kg). All subjects performed two sets of 10 sec. maximal isometric contractions of the Ab Wheel Rollout exercise keeping the knees fixed on the floor and the arms taut. To perform the exercise, all subjects were randomly assessed in the following three positions related to the angle between the arms and trunk, in random order: arms aligned vertically with the Ab Wheel Rollout exercise (neutral); 90° and 150°. A rest period of 5 minutes was provided between tests. The sEMG signals were recorded in the following muscles: Latissimus Dorsi; Pectoralis Major; Erector Spinae; Rectus Abdominis.
RESULTS: There were significant increases in Rectus Abdominis muscle activity between: neutral x 90°, neutral x 150° and 90° x 150°. There was a significant increase in Pectoralis Major muscle activity between neutral x 150°.
CONCLUSIONS: The present findings indicate that (a) Ab Wheel Rollout exercise emphasizes the muscle action of the Pectoralis Major and Rectus Abdominis more than the Latissimus Dorsi and Erector Spinae; (b) the level of muscle activation depends on the external force created by the body mass and lever arm from the center of mass.

KEYWORDS: Biomechanics; Exercise performance; Functional exercise.

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INTRODUCTION

Among the many different variables in resistance training, exercise choice is one of the most important for achieving the aims of the program.[1] In addition, it can influence the level of muscle activation that will be used in the movement,[2] thereby potentially mediating muscular adaptations. Because the choice of a specific exercise can generate mechanical and physiological muscle stress, it is essential to define the exercise order during resistance training.

The superficial electromyographic (sEMG) technique is often used to identify the activation of each muscle in different exercises.[3] Many studies have been conducted to define the main muscles used in exercises such as the bench-press,[4-8] the lateral pull-down,[9,10] pullover[11] and other shoulder movements,[12,13] but there are no specific studies about the Ab Wheel Rollout exercise in the literature.

The Ab Wheel Rollout exercise is a very common exercise for improving upper and trunk body strength and power in athletes and recreational exercisers. The prime actions during the Ab Wheel Rollout exercise are shoulder extension (dynamic contraction) and trunk flexion (isometric contraction).[11,14] During the dynamic movement, the Pectoralis Major (sternal portion), Latissimus Dorsi and Teres Major are the major acting muscles,[10,11,13,15-17] while the Rectus Abdominis and te Erector Spinae act active in isometric contractions (trunk

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stabilization). Marchetti and Uchida[11] anlyzed the sEMG of Pectoralis Major and Latissimus Dorsi during dynamic barbell pullover exercise, which can be considered similar to the Ab Wheel Rollout exercise for the shoulder joint movement. The results showed a higher level of activation for the pectoralis major compared to the Latissimus Dorsi during the pullover exercise. Additionally, Ab Wheel Rollout exercise can be mechanically compared to the static prone plank exercise in terms of trunk stabilization (flexors and extensors),[18,19] but the long lever-arm required during Ab Wheel training would conceivably alter muscle activation levels and perhaps the involvement of different trunk muscles.

No previous study to date has endeavored to assess muscle activity during performance of the Ab Wheel Rollout exercise, leaving a gap in the literature about this commonly performed exercise. Therefore, the aim of the present study was to investigate muscle activation of the shoulder extensors and trunk stabilizers by sEMG activity during the isometric Ab Wheel Rollout exercise in different shoulder joint positions.

METHODS

Subjects

Based on a statistical power analysis derived from the IEMG data from a pilot study, it was determined that 8-10 subjects would be necessary to achieve an alpha level of 0.05 and a power (1-β) of 0.80.[20] Therefore, we recruited 8 young, healthy, resistance trained men (age: 25 ± 3 years, height: 178 ± 5cm, and total body mass: 81 ± 2kg, abdominal skinfold: 13 ± 6mm, and 5 ± 1 years of resistance training experience carried out at least 3 times a week on a regular basis) to participate in this study. All subjects who participated had no previous trunk or lower limb surgery/injury. The procedures employed in the study follow the ethical principles governing research with human subjects in accordance with the resolutions of the National Health Council and has been duly approved by the Ethics Committee of University and all subjects read and signed an informed consent document prior to participating.

Procedures

Prior to data collection, subjects were asked to identify their preferred hand for writing, which was then considered their dominant arm. All subjects were right-hand dominant. Volunteers attended one session in the laboratory at which they reported to have refrained from performing any strenuous exercise or other activities of daily living for at least 48 h prior to testing. Prior to testing, subjects performed a brief specific warm-up for 5 minutes by using the equipment, and a familiarization session with all isometric conditions. After warming up, all subjects performed two sets of 10sec. maximal isometric contractions of the Ab Wheel Rollout exercise keeping the knees fixed on the floor and the arms taut.[21] To perform the exercise, all subjects were randomly assessed in the following three positions related to the angle between the arms and trunk, in random order: arms aligned vertically with the Ab Wheel Rollout exercise (neutral); 90 degrees and 150 degrees. Figure 1 portrays the three possitions of this exercise. A rest period of 5 minutes was provided between conditions. Testing was performed at similar times during the day to avoid diurnal variations.

The participants' skin was prepared before placement of the sEMG electrodes. Hair at the site of electrode placement was shaved and the skin was cleaned with alcohol. Bipolar active disposable dual Ag/AgCl snap electrodes were used (1-cm center-to-center spacing), and were placed on the dominant limb over the longitudinal axes of the following muscles:[11,22] Latissimus Dorsi (ascendant fibers) in the direction of the muscle fibers; Pectoralis Major at the center of the muscle belly; Erector Spinae placed at 2 finger width lateral from the Processus Spinalis of L1; Rectus Abdominis (upper portion) on the belly of the first portion. The sEMG signals were recorded by an electromyographic acquisition system (EMG832C, EMG system Brasil, São José dos Campos, Brazil) with a sampling rate of 2000 Hz using a commercially designed software program (EMG System Brasil, São José dos Campos, Brazil). EMG activity was amplified (bi-polar differential amplifier, input impedance = 2MΩ, common mode rejection ratio > 100 dB min (60 Hz), gain x 20, noise > 5 µV), and analog-to-digitally converted (12 bit). A ground electrode was placed on the right clavicle. EMG signals collected during all conditions were normalized to a maximum voluntary isometric contraction (MVIC) against a fixed resistance. Then, two trials of five-second MVICs were performed for each muscle, with a one-minute rest between actions, only for dominant arm. The first MVIC was performed to familiarize the participant with the procedure. For Latissimus Dorsi MVIC, subjects were kept seated on a chair and performed an extension against a fixed resistance in the neutral shoulder position. For Pectoralis Major, subjects kept their arms in maximal flexion and performed a shoulder extension; For Rectus Abdominis and Erector Spinae, subjects were seated on a chair and performed the maximal flexion and extension of the trunk against a fixed position, respectively. Verbal encouragement was given during all MVICs. The order of MVICs was counterbalanced to avoid any potential bias.

Data analyses

All sEMG data were analyzed with a customized Matlab routine (MathWorks Inc., USA). The digitized sEMG data were band-pass filtered at 20-400 Hz using a fourth-order Butterworth filter with a zero lag. For muscle activation time domain analysis, RMS (150ms moving window) was calculated during the MVIC. Isometric

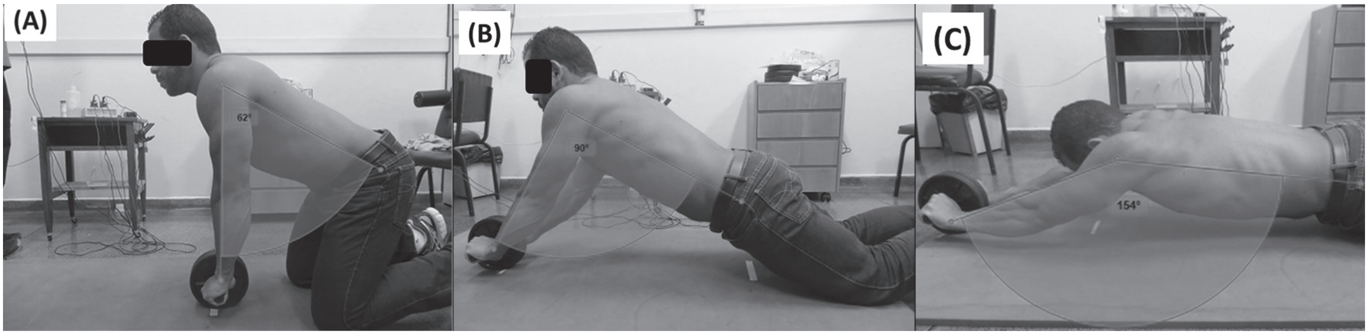

Figure 1 - Ab Wheel Rollout exercise: (A) neutral position; (B) 90 degrees position; and (C) 150 degrees position.

sEMG data was then normalized to the RMS peak of the two peak MVICs, the first second was removed from the normalized RMS, and the following 3 seconds of each trial was integrated (iEMG).

Statistical Analysis

The normality and homogeneity of variances within the data were confirmed with the Shapiro-Wilk and Levenes tests, respectively. To test differences for each muscle activity (iEMG), one-way ANOVAs were used. Post-hoc comparisons were performed with the Bonferroni test. Cohen's formula for effect size (ES) was calculated, and the results were based on the following criteria: < 0.35 trivial effect; 0.35-0.80 small effect; 0.80-1.50 moderate effect; and > 1.5 large effect, for recreationally trained subjects.[23] Test-retest reliability (ICC) was calculated and evaluated based on the following criteria: < 0.4 poor; 0.4 - < 0.75 satisfactory; ≥ 0.75 excellent.[24] An alpha of 5% was used to determine statistical significance.

RESULTS

Test-retest reliability (ICC) of this study ranged between 0.85 and 0.91 (excellent) for all iEMG variables. There were significant main effect to Rectus Abdominis ($p < 0.001$) and Pectoralis Major ($p = 0.001$) for muscle activity during three different positions (neutral, 90º and 150º) in the isometric task. There were a significant increases in Rectus Abdominis muscle activity between: neutral x 90º ($p < 0.001$, Δ% = 97.6%, ES = 2.37); neutral x 150º ($p < 0.001$, Δ% = 98.5%, ES = 5.72), and 90º x 150º ($p < 0.032$, Δ% = 36%, ES = 1.15). There was significant increase in Pectoralis Major muscle activity between neutral x 150º ($p = 0.01$, Δ% = 90%, ES = 1.95) this information is diagrammatically illustrated in Figure 2.

DISCUSSION

The present study investigated the muscle activation of the shoulder extensors and muscles involved in trunk stabilization by sEMG activity during the isometric Ab Wheel Rollout exercise in different shoulder joint positions. Mechanically, the Ab Wheel Rollout exercise begins with the arms positioned vertically aligned with the shoulder and elbow joints.[21] In this position, the lever arm is minimal because the line of action of the force (external) creates a zero external torque. Accordingly, the shoulder and trunk muscles (internal forces) would seemingly have to produce only minimal levels of force to maintain joint stabilization. The present study confirmed that this is indeed the case as all muscles analyzed presented a low iEMG. Regarding the 90º position, a higher level of isometric muscle activation was observed for the Rectus Abdominis and Pectoralis Major, because in this position the center of mass is non-aligned with the shoulder joint creating an external torque that requires greater stabilization by muscles of the trunk (e.g. Rectus Abdominis) and shoulder (e.g. Pectoralis Major). For the 150° position, the center of mass is shifted further forward compared to the 90° position, resulting in the highest level of muscle activation. In these flexed shoulder positions (90 and 150 degrees), the external torque created by the body mass and lever arm from center of mass, produced a movement trend (isometric action) to both shoulder flexion and trunk extension; consequently, and in opposition, an isometric shoulder extension and trunk flexion were produced. Interestingly, muscle activation

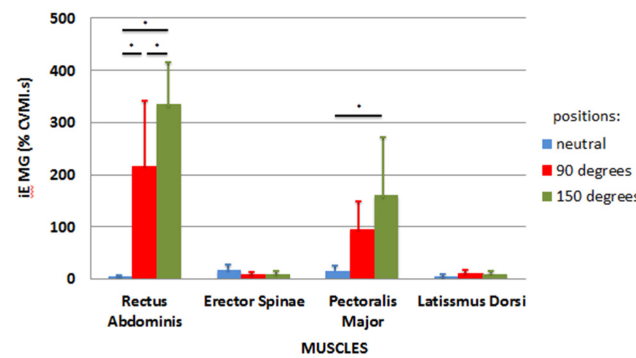

Figure 2 - Mean ± standard deviation of the IEMG from Rectus Abdominis (Rectus Abdominis), Erectus Spinae (ES), Pectoralis Major (Pectoralis Major) and Latissimus Dorsi (Latissimus Dorsi) during isometric Ab Wheel Rollout exercise for different extension shoulder angle-positions (neutral, 90 degrees and 150 degrees) * Significant difference, $p < 0.05$.

was higher in the Pectoralis Major compared to Latissimus Dorsi during performance of the Ab Wheel Rollout exercise. This finding is consistent with previous work by Marchetti and Uchida[11] investigating muscle activation in the barbell pullover exercise. In both studies, the Pectoralis Major was activated as a shoulder extensor when the shoulder was positioned in maximal range of movement in shoulder flexion. The results may be related to changes in the muscle fiber direction during this extreme position, modifying the muscle efficiency to the main movement. In fact, the Pectoralis Major presented a higher activation than the Latissimus Dorsi during all isometric positions, and the highest level of muscle action of Pectoralis Major was related to the greatest lever arm during all positions.

Regarding the trunk stabilizer muscles, the prone plank exercise consists of a prone bridge supported by the forearms and feet, and thus can be considered similar to the Ab Wheel Rollout exercise. The results of present study showed a higher Rectus Abdominis muscle activation when compared to Erector Spinae, corroborating previous work from Tong et al.,[18] Atkins et al.,[25] and Snarr and Esco.[19] Tong et al.[18] studied twenty-eight young male and eight young female athletes by measuring sEMG of selected trunk flexors and extensors (Rectus Abdominis and Erector Spinae) during the static prone plank and found a higher percentage of maximum voluntary isometric contraction (%MVIC) to Rectus Abdominis when compared to Erector Spinae (32.7 ± 10.8 *vs.* 3.3 ± 1.2%MVIC, respectively). Atkins et al.,[25] and Snarr and Esco[19] assessed sEMG of the Rectus Abdominis and Erector Spinae during the prone plank under different conditions (stable and unstable base). Atkins et al.,[25] showed a similar pattern for the rate of muscle contraction on stable base (42.4 *vs.* 10.23% maximal muscle activation, respectively), and Snarr and Esco[19] showed a higher Rectus Abdominis raw sEMG value compared to Erector Spinae (0.81 ± 0.9 *vs.* 0.10 ± 0.04 mV, respectively). Given these findings, it seems that the static prone plank exercise and the Ab Wheel Rollout exercise have similarities with respect to trunk stabilization, and the Rectus Abdominis is substantially more active than Erector Spinae. Finally, we recognize that this study has limitations such as small sample size and the load adjustment using the body weight. Therefore, coaches, athletes, and recreational exercisers need to take these kinesiological factors into account when incorporating Ab Wheel Rollout exercise into program design.

CONCLUSION

In summary, the Ab Wheel Rollout exercise is a common exercise for improving strength, and power, and its principle actions are shoulder extension and isometric trunk stabilization. The present findings indicate that the Ab Wheel Rollout exercise could emphasize the muscle action of the pectoralis major and rectus abdominis more than the Latissimus Dorsi and erector spinae, and the level of muscle activation depends on the external force created by the body mass and lever arm from the center of mass.

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AUTHOR CONTRIBUTIONS:

Marchetti PH: main project, data acquisition, data analyses, text writting; Schoenfeld BJ: text revision; Silva JJ: data acquisition, data analyses; Guiselini MA: data acquisition, data analyses; Freitas FS: data acquisition, data analyses; Pecoraro SL: data acquisition, data analyses; Gomes WA: data acquisition, data analyses; Lopes CR: text revision.

CONFLICT OF INTEREST

Authors declare that there were no conflicts of interest for conducting this study.

PADRÃO ISOMÉTRICO DE ATIVAÇÃO MUSCULAR DURANTE O EXERCÍCIO *AB WHEEL ROLLOUT* EM DIFERENTES POSIÇÕES DO COMPLEXO ARTICULAR DO OMBRO

OBJETIVO: O objetivo do estudo foi investigar o padrão de atividade muscular isométrica de extensores de ombro e estabilizadores de tronco através de eletromiografia de superfície (sEMG) durante diferentes posições do complexo articular do ombro durante o exercício *Ab Wheel Rollout*.

MÉTODO: Foram recrutados 8 voluntários jovens e treinados em força (idade: 25 ± 3 anos, estatura: 178 ± 5 cm, e massa corporal total: 81 ± 2 kg). Os participantes realizaram duas séries de 10 segundos em contração isométrica utilizando o *Ab Wheel Rollout*, e mantiveram os joelhos apoiados no chão e os braços estendidos. Três posições de ombro (em relação ao tronco) foram avaliadas de forma aleatória entre os sujeitos: braços posicionados na vertical e alinhado ao eixo do *Ab Wheel Rollout* (neutra); 90 graus and 150 graus. Um período de cinco minutos foi realizado entre posições e tentativas. Os sinais mioelétricos foram mensurados dos seguintes músculos: Latíssimo do Dorso; Peitoral Maior; Eretores da Coluna; Reto do Abdome.

RESULTADOS: Foi observado um aumento significante da atividade muscular isométrica para o músculo Reto do Abdome entre as posições: neutra x 90°, neutra x 150° e 90° x 150°. Houve aumento significante na ativação muscular isométrica do Peitoral Maior entre a posição neutra x 150°.

CONCLUSÕES: O presente estudo indica que (a) o exercício *Ab Wheel Rollout* enfatiza a ação muscular do Peitoral Maior e do Reto do Abdome em relação ao Latíssimo do Dorso e aos Eretores da Coluna; (b) o nível de ativação mioelétrica depende das forças externas criadas pelo peso corporal e braço de alavanca do centro de massa.

PALAVRAS-CHAVE: Biomecânica; Desempenho físico; Exercício funcional.

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