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Original Article

Electromyographical responses of the lumbar, dorsal and shoulder musculature during the bent-over row exercise: a comparison between standing and bench postures (a preliminary study)

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Abstract:
Rowing exercises are widely used in resistance training. However, from an efficacy and safety standpoint, few science-based recommendations about proper ergonomics performing different rowing variations are currently available. Therefore, the purpose of this study was to examine the electromyographical (EMG) differences between four variations during the dynamic performance of the bent-over row (BOR) exercise: BOR in inclined bench with 90º shoulder abduction (B/AB); BOR in inclined bench with maximum shoulder adduction (B/AD); standing BOR with 90º shoulder abduction (S/AB); standing BOR with maximum shoulder adduction (S/AD). A cross-sectional preliminary study of repeated measures was designed. three young and healthy participants with previous experience in resistance training were recruited from university students of Sport Sciences Degree (mean ± SD age: 21.67 ± 1.21 years; body mass: 75.13 ± 7.00 kg; IMC: 26.15 ± 1.63 kg/m2; % body fat= 9.72 ± 2.41% height: 1.69 ± 9.43 m; training experience: 4.64 ± 1.39 years). Muscle activity was measured using surface EMG in six lumbar, dorsal, and shoulder muscles: posterior deltoid (PD), latissimus dorsi (LD), upper trapezius (UT), middle trapezius (MT), lumbar portion of erector spinae (LES) and thoracic portion erector spinae (TES). Results showed that the two variations based on standing postures (S/AB and S/AD) caused greater EMG responses both on shoulder and lumbar and dorsal muscles. However, importantly, participants had the highest EMG activity on target muscles (deltoid and trapezius muscles) when performing the BOR in a shoulder abduction position (B/AB and S/AB), independent of whether they were, or were not, working with the bench. Thus, considering that the mild activity showed from the lumbar and dorsal back muscles when performing the bench variations would denote lower spine loads, we can conclude that, from an ergonomic standpoint, the use of the bench should be indicated when performing the BOR exercise. However, this is only a preliminary conclusion and the subject needs future analysis.
Key Words: **rowing exercise, ergonomics, lower and upper back, muscle activation, strength training**

Introduction

Strength training has reported important benefits for enhancing the well-being, quality of life and health of individuals (Haraldstad et al., 2017; Lauersen et al., 2018). The effectiveness on the achievement of these goals depends, among other factors, on the correct technical execution and body ergonomics when performing the exercise, which allows and ensures the optimal contraction of the musculature involved while preserving the osteoarticular structures implicated (Häkkinen, 2004; McGill, 2010; Mcweeny et al., 2020). However, acute and chronic musculoskeletal injuries and joint pain caused by poor ergonomics during the execution of resistance exercises are very common (Gabbett, 2016). In this sense, inappropriate practices lacking safety increase the risk of lumbar spine overload and thus the risk of lower back injuries or disorders during high-load strength training (Shaw, 2016; Zyznawska et al., 2019). Therefore, strength and conditioning specialists should know, from an efficacy and safety standpoint, the science-based recommendations for the accurate muscle activation levels and proper ergonomics when performing different resistance training exercises (Lauersen et al., 2018).

The trunk musculature (abdominals and lower and upper back muscles that conform the core), and the scapulohumeral girdle musculature are among the most trained musculature, due to their importance maintaining an optimal body posture as well as preventing back disorders and minimizing the risk of shoulder injury (Nowotny et al., 2018). These muscles are also involved in the daily-life activity or exercise programs of each person or athlete (Zazulak et al., 2008). From the functional training perspective, the different rowing alternatives are among the most used pulling movements for training the back, shoulder and scapular girdle musculature (Cortell-Tormo et al., 2018). Specifically, the bent-over row (BOR) is a fundamental rowing exercise characterized by performing a multiarticular pulling movement which challenges both the trunk

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(abdominals and back) and shoulder muscles (Fenwick et al., 2009). Specifically, the BOR targets the latissimus dorsi (LD), middle and upper trapezius (MT and UT, respectively), posterior deltoid (PD), teres major, rhomboids, lumbar and thoracic portions of the erector spinae muscle (LES and TES, respectively), brachial, brachioradial and biceps brachii muscles (Graham, 2001). Incorrect technique when performing this exercise might cause an excessive overload in the lumbar area as well as poor activation of the dorsal and shoulder area (Fenwick et al., 2009). Additionally, the postural correction during BOR performance, seeking for compensations to avoid pain and overload caused by these technical mistakes, might increase the muscular fatigue, increase neuromuscular deficits, and stop/inhibit the correct performance of the exercise (Asgari et al., 2017; Nowotny et al., 2018). Previous studies have focused on the analysis of the degree of electromyographical (EMG) activation, mobility and the stabilizing musculature stiffness of the trunk in the abdominal and lumbar area during the execution of different rowing variations (Fenwick et al., 2009; Saeterbakken et al., 2015). McGill (2006) observed during the execution of standing BOR an increase in the stiffness of the stabilizing musculature of the trunk. In fact, during the execution of this variant an important activation of both the dorsal and lumbar muscles were observed, which could result in an overload of the lower back.

Despite this previous evidence, the use of the bench as support for the trunk during the performance of this exercise is not common. Moreover, to the best of our knowledge, how the use of the bench affects the EMG response of the muscles involved in this exercise (both trunk stabilizers and targeted muscles) has not been already studied. However, this BOR variation using the bench could be an appropriate alternative from an efficacy, ergonomic and safety standpoint, since there may be possible different EMG activation patterns at lumbar and dorsal areas, which could reduce the lumbar and dorsal overload in the back. Therefore, this preliminary study aims to evaluate the EMG responses of the lumbar, dorsal and shoulder musculature during the performance of different variations of the BOR exercise. Based on previous studies, we have hypothesized that the bench variations will cause a lower EMG response in the lumbar musculature, while the EMG activation levels will be similar or even higher in the targeted musculature (the deltoid and trapezius muscles).

Material & methods

Participants

3 undergraduate students of physical activity and sport science participated in this preliminary study (mean ± SD age: 21.67 ± 1.15 years, height:160.57 ± 9.43 cm, body mass index: 26,145 ± 1.63 and adipose tissue: 9.72 ± 2.41%). According to the preestablished inclusion criteria, subjects with more than one year of experience in resistance training and familiarized with the BOR exercise and the study variations were included in the study. Following exclusion criteria, those with surgeries in the trunk and shoulder musculature, wounds in the electrode placement areas or feeling discomfort or pain during exercises were excluded the study. In addition, subjects could not have a subcutaneous adipose tissue percentage higher than 20% of body mass to minimize eventual EMG artifacts during EMG data collection due to subcutaneous adipose tissue (García-Jaén et al., 2020). All subjects gave informed consent prior to participating in the investigation. This study was conducted according to the guidelines of Declaration of Helsinki and approved by Ethics Committee of the University of Alicante (UA/2018-11-16).

Experimental Design

A cross-sectional study of repeated measures was designed, with a not probabilistic and intentional sample selection, with the aim to analyze the EMG responses of the back and shoulder musculature: DP, LD, UT, MT, LES and TES, while performing four different variations of the BOR exercise using dumbbells. Body composition was firstly determined by an expert anthropometrist. After a previous short familiarization with the instruments and protocols, back and shoulder musculature EMG activation were evaluated during four variations of this rowing exercise: BOR in 45º inclined bench with 90º shoulder abduction (B/AB); BOR in 45º inclined bench with maximum shoulder adduction (B/AD); standing BOR, in a 45º trunk-flexed position with 90º shoulder abduction (S/AB); standing BOR, in a 45º trunk-flexed position with maximum shoulder adduction (S/AD).

Instruments and Data Collection Procedures

For the anthropometric measurements, a wall height rod (accuracy 1 mm), a balance beam scale (100g accuracy), a Cescorf tape measure (1mm accuracy) and a Cescorf plicometer (1mm accuracy) were used. The anthropometry was performed by a level-3 ISAK (*International Society for the Advancement of Kinanthropometry*) certified specialist. Surface electromyography was performed using a high-resolution 6-channel electromyograph from Megaelectronics LTD Wireless logger system (Muscle Tester Mega Win Wireless Bio Amplifer (WBA), Kuopio, Finalandia) using the MegaWin Software, version 3.0. The EMG device is an 8-channel microcomputer with a 14-bit A/D conversion, a 60dB Common-Mode Rejection Ratio and a 12-450 Hz band filter. A sampling rate of 1000Hz was established for EMG measurements. During data collection, the signal produced by the wireless sensors was collected by telemetry signal receivers and then pre-amplified with the use of an analog amplitude differential. This analog signal was converted to a digital signal via an A/D converter (National Instruments NIUSM-6210, New South Wales, Australia). The surface electrodes used were pre-gelled Ag/AgCl. The digital signal was monitored and stored for further interpretation and analyses. The muscle contraction speed was determined by a technological metronome "Soundbrenner", following criteria from previous research (Ekstrom, Donatelli, & Soderberg, 2013). Figure 1 shows the electrode positions and the EMG sensor placement.

Figure 1. Bipolar Surface electromyographic electrode and wireless sensor placement during the performance of the different study conditions.

Testing protocols

All measurements and tests were carried out in the Sports Sciences laboratory of the University of Alicante. In order to preserve the reliability of the EMG data collection, participants were instructed not consume any type of stimulant (e.g., caffeine) or perform exercise during the 48-72h prior to the experimental session. Firstly, a short familiarization session was held to teach, correct and control the proper technique of the BOR exercise with bench and standing in each one of the study conditions (Ekstrom et al., 2003). During the experimental session, participants were firstly instrumented with the EMG wireless sensors. Electrodes were placed on the right side of the back and shoulder, in accordance to accepted international guidelines of *Surface EMG for Non-Invasive Assessment of Muscles* (SENIAM) project, with an interelectrode separation of 20mm (Hermens et al., 2000). Then, they performed different movements to test the quality of the EMG signal.

A maximum voluntary isometric contraction test (MVIC) was carried out for each muscle analyzed, aiming to normalize as a percentage the values obtained in the EMG procedures with the maximum activation obtained in these MVIC test. Specifically, for the DP, the participant adopted a sitting position, in which the shoulder was placed towards an abduction with the arm slightly outstretched and the humerus with a small medial rotation, exerting a force on the manual resistance of the assistant. In the case of LD, the subject was placed in prone decubitus position with an arm in adduction and medial rotation, exerting force against the resistance in the lateral direction from one of the assistants. In the case of LES and TES, the subject was prone lying on the stretcher and with his hands behind his head, the trunk lying on the edge of the surface at the height of the iliac ridges. The subject had to perform an extension of the trunk at its maximum range of motion. In the case of the MT musculature, the participant was in prone decubitus position with a 90º abduction of the shoulder and in lateral rotation, so that the scapula performed a lateral rotation at the lower angle, exercising a force in the opposite direction to the descending force of the assistant. Finally, for the UT, the subject, placed in a sitting position, had to raise the end of the acromion and the collarbone upwards, pretending to carry the occipital bone towards the shoulder with the face facing the opposite side. All of these MVIC protocols were performed following criteria from previous research (Kendall et al., 2005).

Finally, the experimental conditions based on the BOR exercise variations were carried out, using a pair of 12kg dumbbells. In the case of the standing row exercise, the angle of the hip during the trunk flexion in the exercise execution was controlled about 45º, resulting a mean position of 47.67 ± 6.66º. For the bench variations of the BOR exercise, a standard angulation of the bench, placed in a 47º position was established for all participants. The shoulder abduction in the BOR variations was stablished in a 90º angulation, and for the shoulder adduction variations, the arm was totally closed to the trunk, without limiting the range of shoulder extension during BOR performance. Figure 1 shows these controlled positions. Three repetitions of each experimental condition were performed. Considering the first repetition as adaptation to speed and rhythm and the last one as a repetition with accumulated fatigue, the concentric phase of the second repetition was finally determined as the valid repetition for the further analysis, (Fenwick et al., 2009). More details of the EMG procedures used in previous studies are available (Cortell-Tormo et al., 2017; García-Jaén et al., 2020). A metronome was used to control the rhythm of execution of the exercises, because there is a linear relationship between force production and EMG data collection, if the execution rhythm of the concentric and eccentric phase is similar. (Ekstrom, Donatelli, & Soderberg, 2013).

Statistical analyses

The EMG signal was extracted and examined using the software MegaWin Software 700046 version 3.0. Data statistical analysis was performed with SPSS 24.0 (SPSS Inc. Chicago, IL, USA). Given the small sample size (preliminary study), non-parametric statistics (Friedman and pairwise Wilcoxon test) were performed to compare the differences in the EMG responses of the muscles measured during each experimental study in each muscle group. Statistical significance was set at $p \leq 0.05$. All variables are reported as mean ± SD.

Results

Mean and SD values of the normalized EMG muscle activity and Friedman test results for PD, LD, UT, MT, LES and TES are presented in Table 1.

Table 1. Mean and SD values of the normalized EMG and Friedman test results.

Bent-Over Row (BOR) exercise					
	%MCIV Bench BOR		%MCIV Standing BOR		
	Abduction	Adduction	Abduction	Adduction	
Musculature	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	k
Posterior Deltoid	74.33 ± 29.67	63.33 ± 20.55	81.66 ± 32	64.66 ± 23.03	0.199
Latissimus Dorsi	29.67 ± 13.05	42 ± 32.08	43.33 ± 23.76	44 ± 25,87	0.468
Upper Trapezius	88,33 ± 77,69	39,66 ± 21,83	95,67 ± 61,40	50,67 ± 24,21	0.056
Middle Trapezius	53 ± 17,35	31,67 ± 6,43	52,33 ± 3,21	50 ± 14,18	0.122
Lumbar Erector Spinae	23,67 ± 17,21	52,67 ± 5,86	70,67 ± 23,35	74,67 ± 10,41	0.086
Thoracic Erector Spinae	42,33 ± 13,05	16,66 ± 10,79	67 ± 39,15	52 ± 36,67	0.086

The results showed how the variations of the bench caused a lower activation of the LES and TES. Regarding the upper back area, the PD and UT were the muscles that showed the greatest activation during the B/AB variant, while the LD and MT showed the least activation in this experimental condition. Regarding the B/AD variation, once again the PD was the muscle with the highest %MCIV. However, it was observed an activation of the trapezius much lower than expected, while the activation of the LES was 36% higher than the TES activation. In general, it can be observed how the B/AB variant caused a greater activation of all the target muscles and more specifically of the PD and UT. Second, as expected, the standing variations caused elevated erector spinae activations, while maintaining PD and UT activation. These EMG responses were higher in the abduction variation and very similar to the B/AB variation. Figure 2 shows the EMG muscle activation for each of the analyzed back and shoulder musculature in the different study conditions.

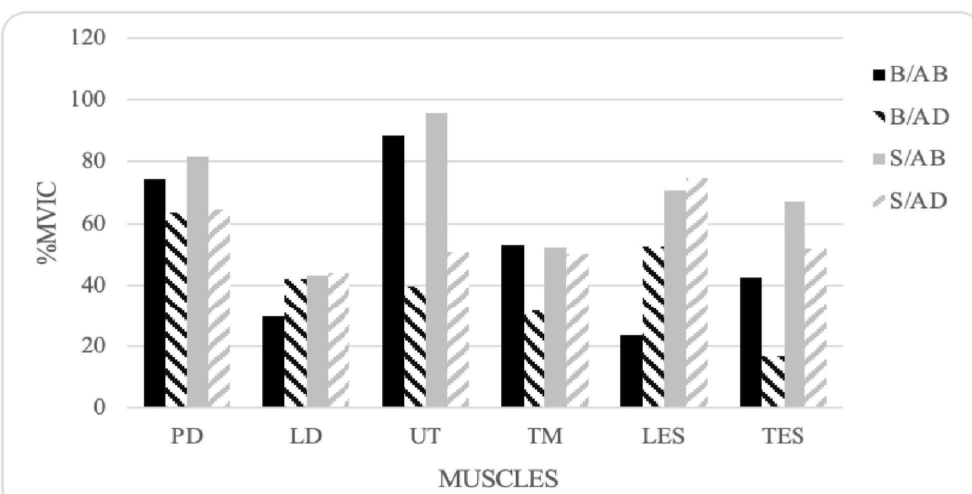

Figure 2. EMG muscle activity in each experimental condition.
B-AB: Bench Bent-Over Row Abduction; S-AB: Standing Bent-Over Row Abduction; B-AD: Bench Bent-Over Row Adduction S-AD: Standing Bent-Over Row Adduction

The results for the comparisons between the different experimental conditions are presented in the Table 2. Despite observing a greater activation of the lower back area when the exercise was performed standing up, these differences were not significant. Regarding PD and MT, although the differences were not significant, a better activation was observed both in the bench and in standing position, being more accentuated in abduction rather than in adduction for both cases, but there were no significant differences between these conditions.

Table 2. P values resulting from non-parametric Wilcoxon test for comparisons between experimental conditions.

Muscles	B-AB vs S-AB	B-AD vs S-AD	B-AB vs B-AD	S-AB vs S-AD	B-AB vs S-AD
Posterior Deltoid	0.109	0.655	0.285	0.109	0.109
Latissimus Dorsi	0.180	0.593	0.285	0.655	0.180
Upper Trapezius	1.000	0.109	0.109	0.109	0.180
Middle Trapezius	1.000	0.109	0.109	0.593	0.593
Lumbar Erector Spinae	0.109	0.109	0.109	1.000	0.109
Thoracic Erector Spinae	0.285	0.109	0.109	0.109	0.593

B-AB: Bench Bent-Over Row Abduction; S-AB: Standing Bent-Over Row Abduction; B-AD: Bench Bent-Over Row Adduction S-AD: Standing Bent-Over Row Adduction

Discussion

This preliminary study aimed to explore the potential differences in the EMG muscular responses from the lumbar, dorsal and shoulder regions during the performance of the BOR exercise using the bench or being in standing position and performing additionally the exercise with a shoulder in abduction or adduction positions. Moreover, this investigation pretended to determine how bench influences the EMG response of the lower-back stabilizer muscles, and how it impacts on the activation of the target upper back and shoulder musculature during the BOR exercise. As far as we know no previous study has compared the four variants of the rowing exercise presented in this work. However, there is evidence that BOR or inverted row exercise causes an optimal activation of the upper and lower back muscles and even abdominal musculature in some exercise variations (Fenwick et al., 2009).

The results showing that the standing row variations caused greater activation levels of overall the muscles analyzed, although without showed significant differences, probably due to this only being a preliminary study using a small sample size without enough statistical power. For that reason, the interpretation of the results must be cautious and limited to preliminary hypotheses. Importantly, the bench BOR variations maintained similar activation values compared to standing BOR variations for Posterior Deltoid and Upper Trapezius muscles, the main targeted muscles of this exercise. Other previous works have analyzed the activation of the back musculature including in some cases the core musculature, with different variants of the Row exercise. For instance, Youdas et al. (2016), when comparing the inverted rowing with two or one leg and with prone and supine grip, concluded that all variants analyzed caused high muscle activation in addition to being appropriate for the strength training of the brachii biceps, latissimus dorsi, trapezius and posterior deltoids. Also, Oliva-Lozano and Muyor (2020), in their review where they analyzed free-weight exercises, including row and inverted row variations and showed that the free-weight exercise produced a high activation of trunk musculature. Referring to the shoulder positions and rowing grip, some previous studies have analyzed the EMG activation differences based on these variables. Krings et al. (2021) measured the force of 1RM with modifications to the bar grip diameter, seeing that for the bent-over 1RM force was smaller when working with a thick grip with the shoulder in abduction position. In contrast, Leslie and Comfort (2013) concluded that an increase in grip width and shoulder abduction showed no significant differences compared to the narrower grip and shoulder adduction during the pull ups. Our results showed greater, although not significant, EMG activation when the BOR exercise was performed in 90º shoulder abduction, which could be also extrapolated to a wide bar grip.

Finally, there is previous evidence that BOR is one of the most active exercises for shoulder, upper and lower back musculature (Lane et al., 2019). These results may be comparable to those obtained in the present study. Although without statistical significance, the standing BOR variations caused higher EMG activation values than the bench variations in the lumbar and dorsal musculature. Similarly, Saeterbakken et al. (2015) showed that the EMG activation of erectors spinae and multifidus was greater when the rowing exercise was performed in a standing position and bilaterally, since a greater activation of the stabilizing musculature is needed when the exercise is performed on different planes of movement. Importantly, the higher EMG activation of the lumbar musculature may be explained in the standing BOR variation due to the moment of force caused by the force of gravity. This means that a postural correction is required, activating the stabilizer and erector muscles of the spine, with the consequent increase of muscle stiffness and spinal load on the lumbar zone (Fenwick et al., 2009). Interestingly, our results showed how the EMG activation of these back muscles was lower when the bench was used to perform the BOR exercise. In this case, the front part of the trunk is supported by a stable surface, thus reducing the impact of gravity force during exercise execution and allowing the least involvement of the erector spinae muscles, with the consequent lower muscular stiffness and lower load on the lumbar spine (Saeterbakken et al., 2015). Although these differences among standing and bench conditions were not significant, it is important to note the trend in significance on the results showed in Table 2. Possibly, futures studies with a greater sample size and statistical power could show significant differences on EMG activation using the bench to perform the BOR exercise, compared to the standing BOR variation. Consequently, the interpretation of the results is limited to this preliminary study.

Conclusions

The standing BOR exercise elicited the highest muscle response on both the shoulder, as well as on the lower and upper back musculature analyzed. However, participants had significant muscle activation in deltoid and trapezius muscles when the shoulders were placed in an abducted position, independent of use of the bench. Since the use of the bench elicited similar EMG values to standing BOR on these target muscles when performing shoulder abduction and considering that the modest muscle activation for the back musculature in the bench variations would indicate lower spine loads, from an efficacy, ergonomics, and safety standpoint the use of the bench should be recommended during the performance of the BOR exercise. These are preliminary conclusions that need more investigation through future studies with a greater statistical power by including a higher sample size.

Conflicts of interest - The authors declare no conflict of interest.

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