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Section I – Kinesiology

High-Density Surface Electromyography Excitation of Prime Movers in the Narrow vs. Wide Grip Seated Row Exercise

by
Riccardo Padovan [1,], Emiliano Cè [1], Stefano Longo [1], Gianpaolo Tornatore [1], Camilla Trentin [1], Fabio Esposito [1], Giuseppe Coratella [1]*

The current study compared the spatial excitation of prime movers during the seated row with a narrow (narrow-SR) or a wide grip (wide-SR) using high-density surface electromyography (HD-sEMG). Fourteen resistance-trained men performed both variations of the exercise using 8-RM (repetition maximum) loads. HD-sEMG amplitude and excitation centroids for the upper/middle/lower trapezius, the latissimus dorsi, the lateral/posterior deltoid, the biceps brachii, the triceps brachii, and the erector spinae were recorded during concentric and eccentric phases. Overall, the narrow-SR showed greater EMG amplitude of the latissimus dorsi in both phases (ES = 1.08), whereas the wide-SR elicited higher excitation for the upper trapezius (ES = 1.35 concentric; ES = 2.79 eccentric), middle trapezius (ES = 1.24; 1.44), lower trapezius (ES = 0.90; 0.71), lateral deltoid (ES = 1.03; 0.58), and erector spinae muscles during the eccentric phase only (ES = 0.65). During the concentric phase, the narrow-SR showed a more lateral centroid of the lateral deltoid (ES = 0.67). During the eccentric phase, the narrow-SR showed a more medial centroid of the middle trapezius (ES = 0.95) and the biceps brachii (ES = 0.90), whereas the centroid of the posterior deltoid (ES = 0.87) was more lateral. Additionally, the centroid was more caudal in the narrow-SR for the erector spinae (ES = 0.74). While the wide-SR appears more appropriate to emphasize the entire trapezius and lateral deltoid, the narrow-SR seems better suited for prioritizing the latissimus dorsi. Whereas these distinctions highlight the preferential excitation of certain muscles, it is important to recognize that both multi-joint exercises recruit several muscle groups, and the specificity of one does not imply the absence, but rather a lesser involvement, of others.

Keywords: *resistance training; EMG; strength training; muscle activity; eccentric*

Introduction

Resistance training is performed by targeting muscle groups through specific exercises (Coratella, 2022), and the particular biomechanical characteristics of each exercise combine the mechanical and neural stimuli underneath that thrive the training-induced increments in strength and structural adaptations (Duchateau et al., 2021; Schoenfeld, 2010; Suchomel et al., 2018). Notably, recent evidence suggests that targeted resistance training can not only improve performance but also alter prime mover muscle excitation patterns, highlighting the adaptive potential of neuromuscular recruitment (Stronska et al., 2022). Understanding how each muscle group is involved during a given exercise may thus provide insight into the unique neuromuscular stimuli (Vigotsky et al., 2018).

Surface electromyography (sEMG) provides insights into the neural activity of each muscle group, allowing for the quantification of muscle excitation and recruitment (Vieira and Botter, 2021). This has led to an extensive investigation of different variations in several exercises such as the squat (Clark et al., 2012; Coratella et al., 2021; van den Tillaar et al., 2019), the deadlift (Andersen et al., 2019; Coratella et al., 2022c; Martín-Fuentes et al., 2020), the bench press (Cabral et al., 2022; Coratella et al., 2020; Stastny et al., 2017), vertical tractions (Andersen et al., 2014; Padovan et al., 2024b; Sperandei et al., 2009), the biceps curl (Coratella et al., 2023a, 2023b; Marcolin

[1] *Department of Biomedical Sciences for Health, Università Degli Studi di Milano, Milan, Italy.*
* Correspondence: riccardo.padovan@unimi.it

et al., 2018), the pulley (Saeterbakken et al., 2015; Vasconcelos et al., 2023) and the overhead press (Błażkiewicz and Hadamus, 2022; Padovan et al., 2024a; Paoli et al., 2010). Beyond exercise selection, EMG has also been used to study the effects of movement characteristics such as the distinction between concentric and eccentric contractions and variations in repetition speed (Golas et al., 2018; Wilk et al., 2018b), which are known to influence muscle excitation. Notably, while pushing movements like the bench press are well represented in the literature, their antagonistic counterparts, such as rowing exercises, remain relatively underexplored despite their relevance for balanced resistance training programs.

In recent years EMG has undergone significant technological advancements evolving into high-density surface electromyography (HD-sEMG), providing the possibility to include spatial mapping of the EMG signal and extending beyond the common quantitative analysis of the prime movers' excitation (Vieira and Botter, 2021). The HD-sEMG offers deeper insights into how various muscles contribute to resistance exercises (Vieira and Botter, 2021), measuring the excitation of the fascicles beneath the electrode grid and calculating an average spatial excitation, represented as the muscle excitation centroid within the mediolateral and craniocaudal planes (Vieira and Botter, 2021). To date, HD-sEMG has been used to examine the spatial difference in hamstring muscle excitation when performing various exercises (Hegyi et al., 2019) and to compare different lat pull-down (Padovan et al., 2024b) and bench press variations (Cabral et al., 2022).

When focusing on the upper-body muscles involved in the pulls, resistance exercises may be performed using a vertical trajectory on the frontal plane (Andersen et al., 2014; Padovan et al., 2024b) and a horizontal trajectory on the sagittal plane (Vasconcelos et al., 2023). The prime movers' excitation in different variations of the vertical traction has been previously investigated by examining the EMG signal amplitude (Andersen et al., 2014; Sperandei et al., 2009) and the centroid placement by HD-sEMG (Padovan et al., 2024b). As for the sagittal plane, pulls may be performed using barbells or dumbbells (both uni- and bilaterally) or a seated row (SR) (Fenwick et al., 2009; Vasconcelos et al., 2023). In this last case, the SR may have a narrow (narrow-SR) or a wide (wide-SR) grip, providing different stimuli. A previous study reported that the excitation of the upper trapezius, middle trapezius, and posterior deltoid muscles increased as the humerus abduction angle increased (60° and 90°), while latissimus dorsi excitation increased as the abduction angle was closer to 0° (Vasconcelos et al., 2023). However, no information is available on spatial recruitment using HD-sEMG.

Therefore, the present study aimed to explore the spatial excitation patterns of the primary muscles during the narrow-SR and wide-SR exercise in resistance-trained people. While pushing movements have been extensively investigated, limited evidence exists on pulling exercises such as the seated row, particularly regarding their spatial EMG characteristics. Furthermore, only few studies have analyzed how concentric and eccentric phases influence spatial muscle excitation in these exercises, despite their known role in acute (Duchateau and Enoka, 2016), short-term (Coratella and Bertinato, 2015), and long-term adaptations (Coratella et al., 2022a, 2022b). The results of this study may help further characterize each grip variation and support their application as specific neuromuscular stimuli in resistance training.

Methods

Study Design

This research was planned as a cross-over, within-subject design with repeated measures, following previously established procedures (Cabral et al., 2022; Coratella et al., 2023b; Padovan et al., 2024b). Participants joined three distinct sessions. The first session permitted participants to familiarize themselves with narrow- and wide-SR techniques and to determine electrode positioning for all target muscles. In the second session, the 8-repetition maximum (8-RM) for both SR variations was tested, with the sequence randomized (Padovan et al., 2024b). In the third session, maximum voluntary isometric contraction was first recorded for each muscle, followed by at least 10 min of passive recovery. Subsequently, surface electromyography (EMG) data were collected during a non-exhaustive set of both SR variations, using a load equivalent to each participant's 8-RM and performing four repetitions to prevent fatigue. Each session was spaced at least three days apart, and participants were instructed to refrain from any additional resistance training during the study duration.

Participants

A convenience sample of fourteen resistance-trained male participants (age 24.86 ± 3.74 years; body height 1.74 ± 0.06 m; body mass 76.22 ± 5.73 kg) was part of the study (Cabral et al., 2022; Hegyi et al., 2019; Mancebo et al., 2019; Padovan et al., 2024b). All participants had at least three years of experience in resistance training. Based on self-reported records within the prior month, participants had an estimated one-repetition maximum (1RM) of 1.35 ± 0.11 × body mass for the bench press and 1.65 ± 0.12 × body mass for the back squat, indicating a trained to well-trained performance level (Maszczyk et al., 2020). Eligibility criteria required the absence of musculoskeletal injuries in the glenohumeral joint, upper limbs, or the spine within the past six months. Additionally, participants were instructed to abstain from caffeine, alcohol, and other stimulants for 24 h before testing. The study was approved by the ethics committee of the University of Milan, Milan, Italy (approval code: CE 11/23; approval date: 09 February 2023) and conducted following the Declaration of Helsinki (1964, with subsequent updates) for research involving human participants. The study participants were thoroughly informed about the research aims and procedures, provided written informed consent, and were notified of their right to withdraw from the study at any time.

Exercises Technique

Participants were placed on a seated row machine [Technogym, Cesena, Italy] to perform both a narrow-SR and a wide-SR. The technique of both exercises is illustrated in Figure 1. A triangle grip [Technogym, Cesena, Italy] was used for the narrow-SR, and a bar [Technogym, Cesena, Italy] was used for the wide-SR. For the narrow-SR, participants began the movement with straight elbows, slightly flexed knees, torso perpendicular to the ground, shoulders protracted, and shoulder blades adducted. From this position, they initiated the pull by adducting the shoulder blades, extending the humerus, and flexing the elbows, finishing when the triangle touched the belly. An observer visually monitored the movement throughout. For the wide-SR, the starting position was similar, with a different endpoint of the concentric phase with the bar touching the lower part of the pectoralis major. During the eccentric phase, the trunk remained fixed without any extension or flexion. At the end of the eccentric phase, participants held the load in an isometric position for 0.5 s before beginning the concentric phase, completing the full range of motion (ROM) as described in standard resistance exercise protocols (Coratella, 2022). For both exercises, each phase—concentric and eccentric—was performed over 2 s, marked by a metronome, with an isometric pause of around 0.5 s. The chosen tempo was adopted to standardize time under tension and avoid potential confounding effects of movement speed on muscle excitation, as tempo has been shown to significantly affect training volume and neuromuscular responses (Wilk et al., 2018a). Participants received visual feedback on timing throughout each lift (Padovan et al., 2024b).

8-RM Protocol

The 8-RM was evaluated using the previously described technique, following established protocols (Padovan et al., 2024a, 2024b). Participants first completed a standardized warm-up, performing three sets of 15 repetitions of the SR using progressively heavier self-selected loads that were assigned individually. Identifying the 8-RM load involved gradually raising the load until the participants could not conclude the 8th repetition during the concentric phase, implying failure (Kompf and Arandjelović, 2016). A minimum of three minutes of passive rest separated every participant's attempt; participants also received verbal encouragement to maximize effort in each trial. This procedure was carried out for both SR exercises in randomized order. The 8-RM load was chosen because it represents a moderate-to-heavy intensity typically used in resistance training for hypertrophy and strength, while also allowing for sufficient repetition volume to capture consistent HD-sEMG data without compromising movement quality.

Muscle Excitation Detection

The signal coming through EMG was collected utilizing semi-reusable high-density electrode grids following a configuration of the 13 x 5 arrangement (GR08MM1305 model, 8 mm inter-electrode spacing, OT Bioelettronica, Turin, Italy) during both SR exercises. Muscles on the dominant side were monitored, including the upper trapezius, middle trapezius, lower trapezius, latissimus dorsi, lateral deltoid, posterior deltoid, biceps brachii, triceps brachii, and erector spinae muscles. For lateral deltoid, posterior deltoid, biceps brachii, triceps brachii, and erector spinae muscles, grids were aligned to the muscle fibers and placed lengthwise (Barbero et al., 2012). The grids were laid down perpendicularly to muscle fibers on the upper trapezius, middle trapezius, lower trapezius, and latissimus dorsi muscles (Vieira and Botter, 2021).

The area of innervation was not taken into account for the upper trapezius, middle trapezius, lower trapezius, latissimus dorsi, and erector spinae muscles according to the "Atlas of Muscle Innervation Zones" (Barbero et al., 2012), whilst the positioning of the grid was also placed in the innervation area for the lateral deltoid, posterior deltoid, biceps brachii, and triceps brachii muscles, in line with previous research (Campanini et al., 2022; Merletti and Muceli, 2019; Padovan et al., 2024b; Rodriguez-Falces et al., 2013). For these muscles, the positioning of the grid was carefully located to minimize unwanted signals from adjoining muscles (Vieira and Botter, 2021).

The upper trapezius grid was positioned on the higher section, about 2 cm sideways to the prominent vertebra (Barbero et al., 2012). The middle trapezius grid was positioned about 2 cm sideways to the prominent vertebra, below the upper trapezius grid (Barbero et al., 2012). For the lower trapezius, the grid was placed 2 cm sideways of the spine, above the spinous process of the twelfth thoracic vertebrae (Barbero et al., 2012). The latissimus dorsi grid was placed 2 cm below the scapula inferior angle, parallel to the spine (Barbero et al., 2012). For the lateral deltoid, the grid was aligned in the middle of the lateral epicondyle and the acromion, above the deltoid tuberosity (Barbero et al., 2012). The grid of the posterior deltoid was positioned on the higher portion, about 2 cm from the acromion side edge. For the biceps brachii, the grid was positioned on the proximal part of the muscle belly, aligned with the acromion and the bicep distal insertion (Barbero et al., 2012). Considering the triceps brachii, the application of the grid was done over the long head, at around one-third of the distance from the acromion to the medial epicondyle of the humerus (Barbero et al., 2012). For the erector spinae, the grid was placed 2 cm sideways of the spine, above the spinal processes of the fifth lumbar vertebrae (Barbero et al., 2012). Conductive cream (ac cream, Spes Medica s.r.l., Genoa, Italy) was applied to the cavities of the electrode grid to maintain consistent contact with the skin. Skin preparation included shaving and abrasion with an abrasive paste (Nuprep, Weaver and Company, Colorado, USA). EMG data were collected in monopolar configuration at a sampling rate of 2048 Hz, with a gain of 200 (Casolo et al., 2023), using an electromyography system (EMG-USB2+, OT Bioelettronica, Turin, Italy) (Merletti et al., 2001). Reference electrodes were placed on the wrist (ground electrode) and on the acromion (high-density grid references).

Once the grids were applied, each participant performed maximum voluntary isometric contractions for the targeted muscle in both randomized SR variations with an immovable weight and a fixed elbow position of 90° (Besomi et al., 2020; Vasconcelos et al., 2023), obtained using a cable extension. Each muscle contraction was performed three times, with each attempt lasting 5 s, and a recovery period of 3 min was provided between attempts (Padovan et al., 2024b). Operators offered standardized verbal encouragement to promote maximal effort during each attempt. Following a 10-min passive recovery, participants engaged in a non-exhaustive set of the narrow- and wide-SR exercise, with the order randomized. A 3-min rest interval separated each set, and the load was set to the previously determined 8-RM. Each set included four repetitions to minimize fatigue and maintain technique consistency. The tempo of 2 s for both the concentric and the eccentric phases was regulated by a metronome, with an operator monitoring the execution to ensure no meaningful change in movement speed occurred.

Muscle Excitation Centroid

Using electrode grids in EMG measurements facilitates the analysis of muscle excitation's spatial distribution across the grid area. To quantify this distribution, the root mean square (RMS) values were used to calculate the barycenter along the vertical (y-axis) and horizontal (x-axis) axes, expressed in millimeters relative to the grid's coordinates. This calculation, known as the central locus of activation, describes how muscle excitation is spatially distributed (Watanabe et al., 2012). The centroid, which represents the barycenter of EMG amplitude values along the grid's rows and columns, was identified for the upper trapezius, middle trapezius, lower trapezius, latissimus dorsi, lateral deltoid, posterior deltoid, biceps brachii, triceps brachii, and erector spinae muscles (Gallina and Botter, 2013).

Data Analysis

EMG data were recorded in a monopolar mode with a gain of 200 (Casolo et al., 2023) and, using a 12-bit analog-to-digital converter with a 5-volt dynamic range, the data were digitized at 2048 Hz. A bandpass filter was applied, spanning 20–400 Hz (Merletti et al., 2001). The root mean square (RMS) was used to characterize EMG signals in the time domain. For maximum voluntary isometric contractions, a 1-s interval was analyzed. The higher value between the two SR variations was used for each muscle. For each exercise, RMS values were calculated and averaged over the central second of both the concentric and eccentric phases. Synchronization between EMG signals and each exercise phase was facilitated by a digital camera (iPhone 12, 12MP resolution, 1080p, 60fps, Apple, California) mounted on a tripod. This setup allowed precise marking of phase transitions in the EMG analysis (Cabral et al., 2022). To ensure consistent execution, the first repetition of each set was excluded from the EMG analysis (Marri and Swaminathan, 2016). The EMG RMS values for each muscle in each exercise were subsequently normalized (nRMS) to the muscle's peak voluntary isometric excitation (Coratella et al., 2023b; Padovan et al., 2024b).

Using MATLAB version R2023B (The MathWorks, Inc, Natick MA, USA), a color map of muscle excitation was created from the RMS values of all 64 grid channels (Figure 2). To obtain color maps, the monopolar EMG signals were bandpass filtered (20–400 Hz) and differentiated into 12 or 4 single-differential EMG signals, depending on the orientation of the fibers relative to the matrix orientation (Cabral et al., 2022). Subsequently, their RMS amplitude was computed. Only active channels, identified as those detecting surface EMG signals with RMS amplitude exceeding 70% of the maximum amplitude across the electrode matrix, were included in the subsequent analysis (Cabral et al., 2022). The 70% amplitude threshold was selected due to its proven effectiveness in accurately identifying channels located above highly active fibers (Vieira et al., 2010). The number and the interquartile range of active channels were then computed to evaluate the spread of the RMS amplitude distribution. Additionally, the barycentre of these active channels, defined as the weighted average of their coordinates, was calculated to assess where along the matrix cranio-caudal and medial-lateral axis EMG amplitude was most strongly represented. The location of the centroid was determined by translating the position of each electrode in the matrix into x- and y-coordinates, measured in millimeters along the two axes (Padovan et al., 2024b). The central second of the ascending and descending phases was analyzed to exclude the transition moments between the phases from the analysis.

Statistical Analyses

Statistical analyses were conducted using SPSS software version 28.0 (IBM, Armonk, NY, USA). Data normality was checked with the Shapiro-Wilk test, which confirmed that all distributions were normal. Descriptive statistics for the 14 participants were presented as mean (SD). To examine differences in normalized RMS (nRMS) and centroid positions between the narrow- and wide-SR exercises across the concentric and eccentric phases, a two-way repeated-measures ANOVA was performed for each muscle. Bonferroni correction was applied for multiple comparisons, and results were reported as mean differences with 95% confidence intervals (95% CI). Statistical significance was set at $\alpha < 0.05$. The magnitude of main effects and interactions was determined using partial eta squared (ηp^2) and classified as trivial (≤0.009), small (0.010–0.059), medium (0.060–0.139), or large (≥ 0.140) (Cohen, 1988). Pairwise comparisons were presented as means with 95% confidence intervals and effect sizes (ES) based on Cohen's d. Effect sizes were interpreted following Hopkins' guidelines: trivial (0.00–0.19), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), and very large (≥ 2.00) (Hopkins et al., 2009).

Results

The average 8-RM load was 50.2 (5.7) kg for the narrow-SR and 41.4 (5.7) kg for the wide-SR ($p < 0.01$, ES = 2.50, 1.42 to 3.56).

Figure 3 displays the nRMS recorded from all muscles during the concentric and eccentric phases of the narrow- and the wide-SR. An interaction between the exercise and the phase was observed for the nRMS in the latissimus dorsi (F = 7.883, $p = 0.015$, $\eta p^2 = 0.377$), and the lateral deltoid (F = 10.344, $p = 0.007$, $\eta p^2 = 0.443$), while no interaction was observed in the upper trapezius (F = 3.330, $p = 0.091$, $\eta p^2 = 0.204$), middle trapezius (F = 3.521, $p = 0.083$, $\eta p^2 = 0.213$), lower trapezius (F = 3.546, $p = 0.082$, $\eta p^2 = 0.214$), posterior deltoid (F = 1.469, $p = 0.247$, $\eta p^2 = 0.102$), biceps brachii (F = 3.000, $p = 0.107$, $\eta p^2 = 0.187$), triceps brachii (F = 0.169, $p = 0.687$, $\eta p^2 = 0.013$) and erector spinae muscles (F = 0.042, $p = 0.841$, $\eta p^2 = 0.003$). In the concentric phase, the nRMS was higher in the wide- than the narrow-SR in the upper trapezius (19.17%, 11.45% to 26.89%; ES = 1.35, 0.63 to 2.05), middle trapezius (18.72%, 10.51% to 26.93%; ES = 1.24, 0.54 to 1.91), lower trapezius (16.68%, 6.61% to 26.74%; ES = 0.90, 0.29 to 1.49) and lateral deltoid muscles (19.79%, 9.34% to 30.24%; ES = 1.03, 0.39 to 1.65), although the nRMS was greater in the narrow-SR in the latissimus dorsi (23.67%, 11.81% to 35.53%; ES = 1.08, 0.43 to 1.71), while the posterior deltoid, biceps brachii, triceps brachii and erector spinae muscles had similar excitation ($p > 0.05$). During the eccentric phase, the nRMS was higher in the wide- than in the narrow-SR in the upper trapezius (12.57%, 10.29% to 15.68%; ES = 2.79, 1.61 to 15.02), middle trapezius (11.96%, 7.44% to 16.48%; ES = 1.44, 0.69 to 2.16), lower trapezius (8.56%, 2.03% to 15.08%; ES = 0.71, 0.14 to 1.26), lateral deltoid (7.64%, 0.45% to 14.83%; ES = 0.58, 0.03 to 1.11) and erector spinae muscles (3.76%, 0.06% to 6.93%; ES = 0.65, 0.08 to 1.19), though it was greater in the narrow-SR in the latissimus dorsi (6.97%, 3.47% to 10.48%; ES = 1.08, 0.43 to 1.71), while the posterior deltoid, biceps brachii and triceps brachii muscles had similar excitation ($p > 0.05$).

Figure 4 illustrates the average horizontal and vertical coordinates of the centroid for each muscle during the concentric and eccentric phases of both the narrow- and the wide-SR. An interaction between exercise and the phase was observed for the horizontal coordinates in the upper trapezius (F = 7.119, $p = 0.019$, $\eta p^2 = 0.354$), posterior deltoid (F = 4.917, $p = 0.045$, $\eta p^2 = 0.274$), and biceps brachii muscles (F = 13.784, $p = 0.003$, $\eta p^2 = 0.515$), while no interaction was identified in the middle trapezius (F = 3.170, $p = 0.098$, $\eta p^2 = 0.196$), lower trapezius (F = 0.172, $p = 0.685$, $\eta p^2 = 0.013$), latissimus dorsi (F = 3.414, $p = 0.088$, $\eta p^2 = 0.208$), lateral deltoid (F = 0.297, $p = 0.595$, $\eta p^2 = 0.022$), triceps brachii (F = 3.167, $p = 0.099$, $\eta p^2 = 0.196$) and erector spinae muscles (F = 0.546, $p = 0.473$, $\eta p^2 = 0.040$). During the concentric phase, the centroid was more lateral in the narrow- vs. the wide-SR in the lateral deltoid (1.38%, 0.26% to 2.50%; ES = 0.67, 0.11 to 1.22). No medial-lateral differences in the centroid were found for the upper trapezius, middle trapezius, lower trapezius, latissimus dorsi, posterior deltoid, biceps brachii, triceps brachii and erector spinae muscles ($p > 0.05$). During the eccentric phase, the centroid was positioned more medially in the narrow- vs. the wide-SR in the middle trapezius (4.39%, 1.88% to 6.91%; ES = 0.95, 0.33 to 1.55) and the biceps brachii (3.52%, 1.40% to 5.64%; ES = 0.90, 0.29 to 1.49), while the posterior deltoid (2.73%, 1.03% to 4.42%; ES = 0.87, 0.27 to 1.46) exhibited the opposite behavior, with the centroid positioned more laterally. No medial-lateral differences in the centroid were observed for the upper trapezius, lower trapezius, latissimus dorsi, lateral deltoid, triceps brachii, and erector spinae muscles ($p > 0.05$). The centroid was positioned more laterally in the biceps brachii (4.28%, 1.99% to 6.57%, ES = 1.02, 0.38 to 1.63), while more medially in the posterior deltoid (1.95%, 0.12% to 3.77%, ES = 0.58, 0.03 to 1.11) and the triceps brachii (4.33%, 1.99% to 6.66%, ES = 1.01, 0.37 to 1.62) during the concentric phase compared to the eccentric phase of the narrow-SR. In addition, the centroid was positioned more medially in the triceps brachii (1.85%, 0.15% to 3.55%, ES = 0.59, 0.04 to 1.12) during the concentric phase compared to the eccentric phase of the wide-SR. No additional between-phase differences were observed ($p > 0.05$).

No interaction between exercise and the phase was observed for the vertical axis in the upper trapezius (F = 0.391, $p = 0.542$, $\eta p^2 = 0.029$), middle trapezius (F = 2.982, $p = 0.108$, $\eta p^2 = 0.187$), lower trapezius (F = 0.832, $p = 0.378$, $\eta p^2 = 0.060$), latissimus dorsi (F = 2.741, $p = 0.122$, $\eta p^2 = 0.174$), lateral deltoid (F = 0.303, $p = 0.591$, $\eta p^2 = 0.023$), posterior deltoid (F = 2.451, $p = 0.141$, $\eta p^2 = 0.159$), biceps brachii (F =

2.164, $p = 0.165$, $\eta p^2 = 0.143$), triceps brachii (F = 3.823, $p = 0.072$, $\eta p^2 = 0.227$) and erector spinae muscles (F = 3.809, $p = 0.073$, $\eta p^2 = 0.227$). During the concentric phase, the centroid was more caudal in the narrow- vs. the wide-SR in the erector spinae (13.24%, 3.55% to 22.93%, ES = 0.74, 0.16 to 1.30). No cranio-caudal differences in the centroid were found for the upper trapezius, middle trapezius, lower trapezius, latissimus dorsi, lateral deltoid, posterior deltoid, biceps brachii and triceps brachii muscles ($p > 0.05$). No cranio-caudal differences were observed in the centroid during the eccentric phase between the narrow- and the wide-SR ($p > 0.05$). Additionally, the centroid was more cranial in the middle trapezius (15.64%, 1.69% to 29.60%; ES = 0.61, 0.05 to 1.14), and more caudal in the triceps brachii (41.56%, 26.06% to 57.06%; ES = 1.45, 0.70 to 2.19) and the erector spinae (10.43%, 1.70% to 19.15%; ES = 0,65 0.09 to 1.19) during the concentric phase compared to the eccentric phase of the narrow-SR. Regarding the wide-SR, the centroid was more cranial in the posterior deltoid (10.33%, 0.36% to 20.30%, ES = 0.56, 0.02 to 1.09) with the opposite behavior observed in the biceps brachii (13.59%, 2.29% to 24.88%, ES = 0.65, 0.09 to 1.20) and triceps brachii muscles (26.34%, 13.62% to 39.05%, ES = 1.25, 0.46 to 1.77) during the concentric compared to the eccentric phase. No further between-phase difference was found ($p > 0.05$).

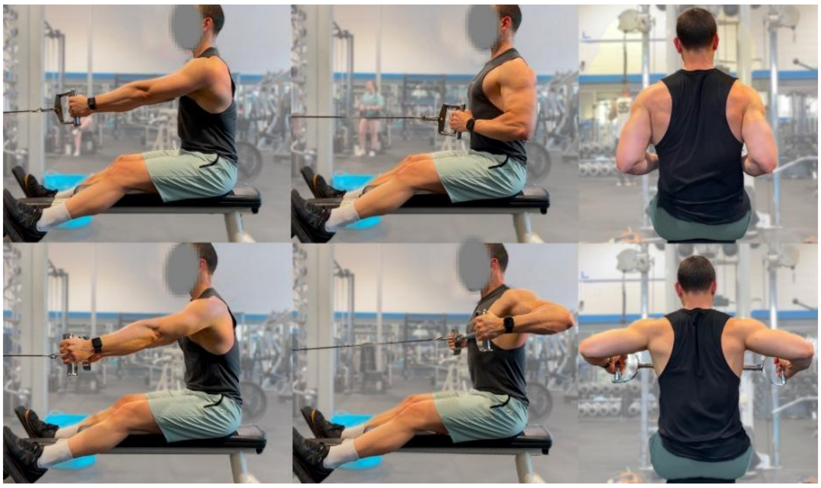

Figure 1. The technique for each exercise, described with a lateral view of the start and a lateral and a posterior view of the end of each movement: (above) narrow grip seated row; (below) wide grip seated row.

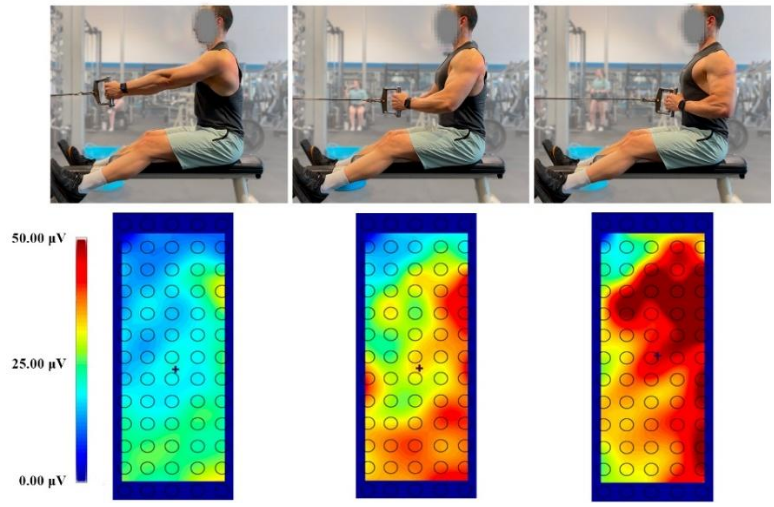

Figure 2. A typical spatial map of the muscle excitation for the latissimus dorsi during a narrow grip seated row. The upper panel shows three distinct positions, and the corresponding spatial excitation is reported below each position. The centroid is represented by the “+”.

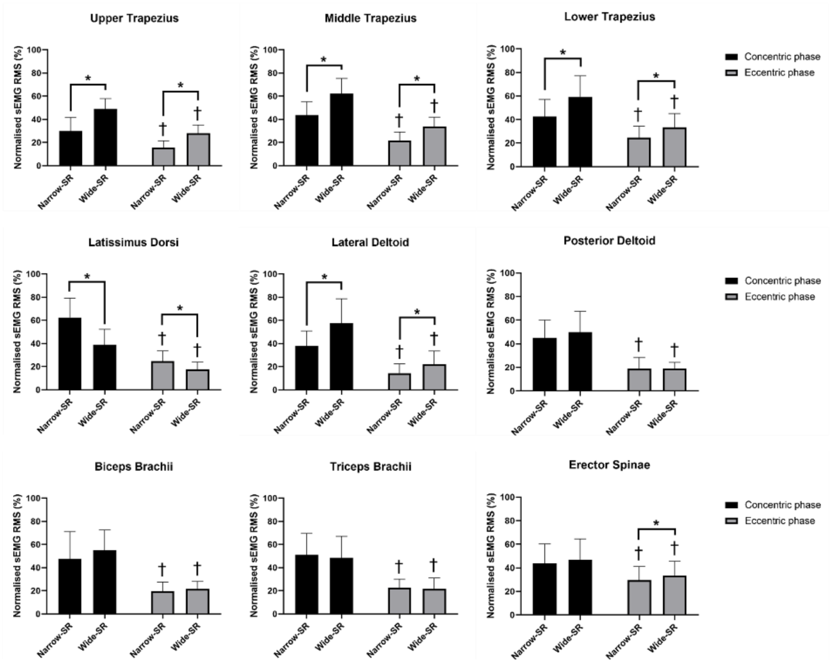

Figure 3. The mean (SD) of the normalized root mean square (nRMS) recorded during the concentric and the eccentric phase of the narrow grip seated row (narrow-SR) and the wide grip seated row (wide-SR) is shown for each muscle. Besides narrow vs. wide seated row differences, the nRMS was greater during the concentric than the eccentric phase in both exercises. ** $p < 0.05$ vs. wide-SR. † $p < 0.05$ vs. eccentric phase*

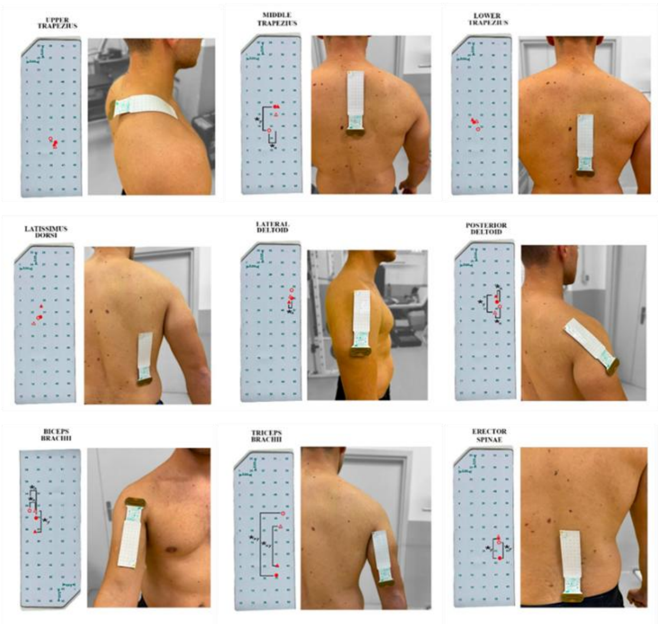

Figure 4. The spatial muscle excitation for the muscles analysed is shown. The grids are visualized as positioned on each muscle. The upward and the downward direction indicates a cranial and a caudal shift on the vertical plane, respectively; the rightward and leftward shifts indicate a lateral and a medial shift on the horizontal plane, respectively. The narrow grip seated row (narrow-SR) is represented graphically by filled circles (●) for the concentric and empty circles (◉) for the eccentric phase. The wide grip seated row (wide-SR) is represented graphically by filled triangles (▲) for the concentric and empty triangles (△) for the eccentric phase. *✱y: $p < 0.05$ comparing the centroid on the vertical y-axis. ✱x: $p < 0.05$ comparing the centroid on the horizontal x-axis*

Discussion

The current study examined the excitation of the prime movers involved in the narrow- and the wide-SR using high-density EMG for the first time and separating the analysis into the concentric and the eccentric phase. The key findings were: i. the narrow-SR showed greater external loads compared to the wide-SR; ii. during the concentric phase, the latissimus dorsi showed higher excitation during the narrow-SR, while upper, middle and lower trapezius, and lateral deltoid muscles showed higher excitation in the wide-SR. During the eccentric phase, the latissimus dorsi showed higher excitation during the narrow-SR, while in the upper, middle and lower trapezius, lateral deltoid, and erector spinae muscles the excitation was higher in the wide-SR; iii. on the medio-lateral plane, during the concentric phase the centroid of the lateral deltoid was more lateral in the narrow-SR, while during the eccentric phase the centroid of the middle trapezius and the biceps brachii was more medial and of the posterior deltoid was more lateral during the narrow-SR; iv. on the craniocaudal plane, during the concentric phase the centroid of the erector spinae was more caudal in the narrow-SR, while no further difference observed. We observed different muscular behavior in the narrow- and the wide-SR.

Before analyzing the excitation of the muscles investigated here, some preliminary considerations to contextualize the results may be helpful. Notably, the absolute external load was generally higher during the narrow- compared to the wide-SR, and although there is no study that has reported such a difference, practitioners could easily rely on their personal experience to corroborate it. Overall, greater loads lead to higher RMS amplitude (Looney et al., 2016), even though the biomechanical properties associated with different exercise techniques can either facilitate or restrict the ability to lift heavier loads (Coratella et al., 2021). This should be considered when evaluating the contribution of each primary muscle. In this context, the variation in hand distance may have caused the muscles to operate at different lengths, which could have impacted the amplitude of the sEMG signal (Vigotsky et al., 2018). Furthermore, we speculate that the external load trajectory could have been longer during the narrow-SR compared to the wide-SR due to the closer hand position and greater initial muscle elongation. A longer trajectory may result in a higher movement velocity when the same tempo for each dynamic phase is given, and the nRMS amplitude tends to increase with faster movements (Frost et al., 2008).

During the concentric phase, the latissimus dorsi showed higher excitation in the narrow-SR, while the upper, middle and lower trapezius, and lateral deltoid muscles showed greater excitation in the wide-SR. Considering the arm position and the resulting different trajectory, the greater humeral extension in the adducted sagittal plane in the narrow- vs. the wide-SR may have elicited greater latissimus dorsi involvement. As for the upper trapezius, the scapula upward rotation during the wide-SR could explain the increased excitation (Escamilla et al., 2009). As to the middle trapezius, the greater demand for the scapular retraction and the more abducted humerus at the end of the concentric phase may have likely contributed to its greater excitation (Escamilla et al., 2009). Regarding the lower trapezius, this may depend on the increased scapular posterior tilt and external rotation of the scapula due to the humeral position in the wide-SR (Escamilla et al., 2009). Considering the arm position between SR variations, the lateral deltoid played a larger role in the humeral abduction (Escamilla et al., 2009) during the wide-SR, which resulted in higher excitation. Additionally, it appears that the entire trapezius worked synergistically with the lateral deltoid to stabilize the load on a more abducted plane, where the latissimus dorsi acts less effectively. Similar excitation patterns were observed in the eccentric phase. Moreover, during the eccentric phase, the erector spinae showed greater excitation in the wide- vs. the narrow-SR. Despite the lower absolute load in the former, the cranial hand position at the start of the eccentric phase in the wide-SR might have increased the lever arm and moved it further from the center of mass, thereby increasing instability and demanding from the erector spinae more pronounced backward stabilization of the trunk.

Despite the greater external load lifted during the narrow-SR (50.2 ± 5.7 kg) compared to the wide-SR (41.4 ± 5.7 kg), the latter condition exhibited greater EMG amplitude in several prime movers such as the upper, middle, and lower trapezius, and lateral deltoid muscles. This finding may appear counterintuitive, as muscle excitation is generally expected to increase with the external load (Looney et al., 2016); however, biomechanical factors likely explain this divergence. The wider grip position in the wide-SR modifies joint angles and lever arms, potentially placing specific muscles at longer lengths and less mechanically favorable positions. These conditions may increase their relative mechanical demand and result in greater excitation despite a lighter absolute load (Coratella et al., 2021; Vigotsky et al., 2018). Moreover, muscle contractile properties can be altered based on the specific demands imposed by different exercise configurations. Resistance exercises with different neuromuscular tasks can induce peripheral fatigue that is detectable through changes in muscle contractility (Piqueras-Sanchiz et al., 2024), which may reflect altered loading patterns and contribute to shifts in muscle contribution and excitation.

The novel approach using HD-sEMG provides a more qualitative assessment of muscle excitation (Vieira and Botter, 2021), distinguishing the placement of the mean excitation within each muscle. It should be noticed that the interpretation of the centroid placement determined by HD-sEMG for each muscle may not follow the muscle anatomical planes, especially when referring to the medio-lateral plane since based on each matrix reference axis. Furthermore, the placement of the centroid on the x- and y-axis, whether transversely or parallel to the fascicle orientation, is related to different mechanisms (Vieira and Botter, 2021). Indeed, while the former provides an overview of the spatial excitation within the muscle and between the main fascicles (Vieira and Botter, 2021), the latter mostly indicates the shift of the innervation zone during dynamic contractions (Mancebo et al., 2019; Vieira et al., 2017), together with the conduction velocity (Vieira and Botter, 2021) not examined here. Regarding the x- and y-axis orientation relative to the fascicle orientation, in some muscles, an axis may be parallel (e.g., x-axis in the middle trapezius), while in others it may be transverse (e.g., x-axis in the lateral deltoid). Lastly, while the electrode matrix collects data from a large muscle surface, it cannot cover the entire muscle due to its unique shape, thus the obtained data pertain only to the analyzed region.

Considering the matrix position in the mediolateral plane transverse to the fascicles, the information obtained is related to the different involvement between different parallel fascicles (Vieira and Botter, 2021), so the fascicles with the greater excitation tend to shift the centroid in their direction. Comparing the narrow- vs. the wide-SR, the centroid of the lateral deltoid was more lateral, i.e., more anterior, during the concentric phase for the narrow- vs. the wide-SR. The different humerus positions (i.e., adducted vs. abducted and externally rotated vs. slightly internally rotated) may have resulted in greater elongation of the anterior fascicles (Fridén and Lieber, 2001; Lorne et al., 2001) during the concentric phase under the narrow-SR condition, which might have increased the mean EMG amplitude (Padovan et al., 2024b). Similarly, the centroid of the posterior deltoid was positioned more laterally—i.e., more anteriorly—during the eccentric phase in the narrow-compared to the wide-SR. The more internally rotated humerus under the wide-SR condition could have favored the elongation and consequent excitation (Padovan et al., 2024b) of medial fascicles (Fridén and Lieber, 2001; Lorne et al., 2001) may explain the posterior fascicles' elongation with subsequent lateral shift in the centroid. The biceps brachii had its centroid shifted medially—i.e., more externally—in the narrow- vs. the wide-SR during the eccentric phase. It is possible that the greater abduction of the humerus in the wide variation could have led to greater engagement of the biceps long head—i.e., the external one—making it slightly more involved than the short head (Chalmers et al., 2014).

Considering the matrix position in the craniocaudal plane parallel to the fascicles, the analysis allows the detection of the EMG signal in the same fascicles along their length (Vieira and Botter, 2021). As such, the centroid is affected by the innervation zone sliding cranially or caudally depending on the fascicle shortening or elongation (Mancebo et al., 2019; Vieira et al., 2017). Consequently, the signal propagates longitudinally from the innervation zone, increasing its amplitude (Mancebo et al., 2019). Considering the middle trapezius, the centroid shifted more cranially—i.e., more medially—in the narrow- compared to the wide-SR during the eccentric phase. In the narrow-SR, the possible greater elongation due to the different ending position could have shortened the fascicles towards their origin at the vertebral level with the consequent innervation zone shift, resulting in more mean medial excitation (Jiroumaru et al., 2014; Padovan et al., 2024b). Focusing on the erector spinae, the centroid was more caudal in the narrow- compared to the wide-SR during the concentric phase. Since its innervation zone does not seem to affect the signal from the surface fascicles (Barbero et al., 2012), its centroid may reflect different levels of involvement among parallel fascicles. As described in the literature, the same muscle can exhibit different regional excitation depending on task requirements and muscle development (Watanabe et al., 2012). In this case, the different arm leverage between the wide- and the narrow SR may have shifted the erector spinae excitation cranially under the wide-SR condition, due to its cranial hand position during the end of the concentric phase.

The participants in this study demonstrated trained to well-trained resistance profiles, with estimated 1RM values of approximately 1.35 × body mass in the bench press and 1.65 × body mass in the back squat. According to classifications proposed by Maszczyk et al. (2020) these values reflect sufficient training background to ensure technical consistency and exercise familiarity, which is essential when interpreting surface EMG data. While neuromuscular patterns can vary based on training status, well-trained individuals tend to show more stable excitation profiles and motor unit recruitment strategies across repetitions, minimizing inter-trial variability. Therefore, the observed spatial excitation patterns are likely representative of experienced lifters and may differ from responses in novice or elite populations.

The present study has some limitations to be acknowledged. First, the outcomes reflect the combination of the described and performed technique, the selected load, and the participants' sports background. Modifying one or more of these factors may influence the results. Second, assessing the excitation of additional muscles could have provided deeper insights. Lastly, although the sample size aligns with previous studies, including more participants could increase the statistical power of the present findings.

Conclusions

In conclusion, the current study found different muscle excitation between the narrow- and the wide-SR. Quantitively, the narrow-SR induced greater excitation of the latissimus dorsi, while the wide-SR of the upper trapezius, middle trapezius, lower trapezius, lateral deltoid, and erector spinae muscles. As for a more qualitative analysis of the muscle excitation through the centroid, mediolateral differences were found in the middle trapezius, lateral and posterior deltoid, and biceps brachii muscles, while cranio-caudal differences were observed in the erector spinae. Overall, the wide-SR exhibited greater prime movers' excitation compared to the narrow-SR, despite being performed with a slightly lower absolute external load. More importantly, the narrow- and the wide-SR do not induce equivalent muscle excitation and should both be used to differently to stimulate the prime movers.

When transferring these outcomes into resistance training practice, the choice of exercise should depend on the specific target. Indeed, the wide-SR seems more appropriate to stimulate the entire trapezius and lateral deltoid muscles especially, whereas the narrow-SR appears more suitable when the focus is on the latissimus dorsi. While such distinctions may characterize each exercise, it is important to remember that multi-joint exercises such as the narrow-SR and the wide-SR stimulate multiple muscles, and the specificity of one or the other does not imply an absence, but just a less specific action of a given muscle.

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ORCID iD:

Riccardo Padovan: https://orcid.org/0009-0000-2090-9164

Emiliano Cè: https://orcid.org/0000-0003-0691-3153

Stefano Longo: https://orcid.org/0000-0001-5806-8305

Gianpaolo Tornatore: https://orcid.org/0000-0002-0187-8371

Camilla Trentin: https://orcid.org/0009-0006-2442-0271

Fabio Esposito: https://orcid.org/0000-0002-4420-2611

Giuseppe Coratella: https://orcid.org/0000-0001-7523-9102

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