**Title page:**

**i) Title:**

Evaluation of Quadriceps Femoris Muscle Electromyographic Activity in Healthy Adult Males During Common Strength Exercises: A Systematic Review

**ii) Authors:**

Masood Saleh Shahreza1, Shahrzad Zandi\*2, Hooman Minoonejad3

**iii) Affiliations:**

1. MSc. Sport Biomechanics, Faculty of Sport Sciences and Health, University of Tehran

2. Assistant Professor, Faculty of Sport Sciences and Health, University of Tehran

3. Associate Professor, Faculty of Sport Sciences and Health, University of Tehran

**iv) running title: Quad muscles activity in strength exercises**

**v) \*corresponding author:** Shahrzad Zandi, Faculty of Sport Sciences and Health, University of Tehran, North Karegar St., Tehran Iran. Tel: +982161118897. Email: shzandi@ut.ac.ir.

**Evaluation of Quadriceps Femoris Muscle Electromyographic Activity in Healthy Adult Males During Common Strength Exercises: A Systematic Review**

**Abstract**

Aims: The primary objective of this study was to systematically review the existing literature on quadriceps femoris muscle activity, as measured by sEMG, in healthy adult males during common strength exercises.

Methods: This systematic review used the PRISMA guidelines. Original research articles published up to December 2023 were retrieved from the PubMed/Medline, Scopus, and Web of Science databases. The inclusion criteria required studies to (a) be available in full-text English, (b) utilize cross-sectional or longitudinal study designs (experimental or cohort), (c) report electromyographic activity as a percentage of maximal voluntary isometric contraction (%MVIC), (d) analyze Rectus Femoris (RF), Vastus Lateralis (VL), and Vastus Medialis (VM) muscles, (e) focus on resistance training exercises as the primary intervention, (f) be published within the last ten years, and (g) include healthy adult male participants.

Findings: The review results indicated that the VL was the most frequently studied quadriceps muscle across different exercises. Notably, the leg press demonstrated the highest activation levels for both the VL and VM, while the Spanish squat elicited the highest activation for the RF. Additionally, the deadlift showed substantial activation of the VL, though to a lesser extent than the leg press.

Conclusions: These findings highlight the importance of exercise selection for targeting specific quadriceps muscles during strength training. Furthermore, to ensure the accuracy and reliability of sEMG data, it is critical to establish standardized methodological criteria for its use.

Keywords

Strength exercises, electromyography, quadriceps muscles, systematic review

**Introduction**

Strength training has been shown to play a protective role against cartilage loss while improving bone tissue mass, tendon health, and muscle function [1]. Despite the well-established connection between muscle-strengthening exercises and overall health and well-being, more than 80% of adults fail to meet the recommended guidelines (≥ 2 times per week), as clinical and epidemiological evidence indicates. Furthermore, public health initiatives for chronic disease prevention have historically focused more on aerobic physical activity than muscle-strengthening exercise [2].

Resistance training has become crucial in strength training programs, particularly for older adults [3]. These programs often include exercises targeting the muscles of the lower limbs, with the quadriceps serving as the primary muscle responsible for movements and locomotion in daily life. Impairments in the mechanical function of lower limb muscles, such as reduced muscle strength, significantly impact lower limb functional capacity [4]. Quadriceps muscle activation, specifically, has garnered considerable attention in the literature [5, 6].

Muscle activation patterns are essential when selecting strength training exercises, as they vary depending on fitness goals such as hypertrophy, performance, or injury prevention [7]. Electromyography (EMG), which captures the electrical signals produced by muscle contractions, offers a valuable tool for assessing muscle activation. EMG data can reflect human movement intentions and facilitate more natural and fluent human-machine interactions by mirroring these physiological signals [8].

To the best of our knowledge, there is no comprehensive review of the current literature on quadriceps muscle activation in adult men, and there is considerable disagreement regarding the specific exercises involved. For example, some studies have shown greater Vastus Medialis (VM) activity during the leg press exercise compared to the squat exercise [9], while Sjöberg et al. (2021) reported similar quadriceps activity in both exercises.

The primary aim of this manuscript is to systematically review the current literature investigating quadriceps femoris muscle activity, measured using sEMG, in healthy adult males during common strength exercises. A deeper understanding of quadriceps activation in these exercises will give researchers, clinicians, trainers, and athletes valuable insights for selecting the most effective exercises for targeting specific muscles.

**Methods**

This systematic review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [10]. The protocol for this review was registered in the International prospective register of systematic reviews (PROSPERO) database. The quality of the included studies was assessed by two reviewers using the Physiotherapy Evidence Database quality scale (PEDro scale), which consists of 11 questions. The final score was proportionally distributed based on the total number of questions answered. However, due to the inability to blind researchers and trainees, three of the 11 questions were excluded, resulting in a maximum score of 8 [11].

On March 21st, 2023, a systematic search was conducted using the PubMed/Medline, Scopus, and Web of Science databases. Medical Subject Headings (MeSH) descriptors, relevant terms, and keywords were employed, with an example of the complete PubMed search strategy as follows:

“resistance training” [Abstract] OR “strength training” [Abstract] OR “resistance exercise” [Abstract] OR “weight lifting” [Abstract] OR “weight bearing” [Abstract]

AND electromyography [Abstract] OR EMG [Abstract] OR “muscle activation” [Abstract] OR “muscle activity” [Abstract] OR “sEMG amplitude” [Abstract] OR “neuromuscular activation” [Abstract] OR “muscle excitation” [Abstract] OR “muscular activity” [Abstract]

AND “thigh muscle” [Abstract] OR “quadriceps” [Abstract] OR “quads” [Abstract] OR “knee extensors” [Abstract].

Only studies that met the following inclusion criteria were selected: (a) full-text availability in English, (b) cross-sectional or longitudinal study design (experimental or cohort), (c) data on electromyographic (EMG) activity as a percentage of maximal voluntary isometric contraction (%MVIC), (d) analysis of RF, vastus lateralis (VL), and VM muscles, (e) focus on resistance training exercises as the primary intervention, (f) published within the last 10 years, and (g) inclusion of healthy adult males.

Studies were excluded if they lacked sufficient data, contained unclear or ambiguous protocols, or were review articles, conference papers, books, theses, or congress abstracts. Samples involving participants with metabolic disorders, musculoskeletal trauma, a history of back pain, spinal cord injury, or neurological deficits were also excluded, as were studies on elderly or young populations. Additionally, studies focusing on aerobic, isometric, plyometric, or calisthenics exercises were excluded.

Two independent reviewers selected the studies based on the inclusion and exclusion criteria. After duplicates were removed, titles and abstracts were screened. The full texts of the remaining articles were then reviewed, and only those that met the inclusion criteria were selected. In cases of disagreement between the two reviewers, a third colleague was consulted to reach a consensus. Figure 1 provides a graphical representation of the study selection process.

624 records returned from the database search

577 records remaining after removing duplicates

Number of records screened by title and abstract = 577

534 records excluded by title and abstract

43 articles assessed by full text

32 records excluded after reading the full texts

11 studies included in the systematic review

**Identification**

**Screening**

**Eligibility**

**Inclusion**

**Figure 1. PRISMA Flowchart.**

The authors analyzed the data in two consecutive meetings to finalize the inclusion of eligible articles in the review. After reviewing each article, the following information was extracted: (1) exercise performed, (2) EMG collection method, (3) electrode placement, (4) target muscles, (5) main findings, (6) average %MVIC values for each exercise, (7) number and age of participants, and (8) reference. For exercises evaluated by two or more studies, data were pooled to calculate the mean %MVIC for each exercise. Only the mean % of MVIC data from each study was used in this analysis.

Quadriceps muscle activation was categorized into the following levels [12]: 0-20%MVIC as low activation, 21-40%MVIC as moderate activation, 41-60%MVIC as high activation, and >60%MVIC as very high activation.

The selected studies reported muscle activation separately for each exercise and muscle group. sEMG activity was the primary data collected, and sEMG data were recorded for both the eccentric and concentric phases when available.

Due to the methodological inconsistencies and varying analyses across studies, conducting a meta-analysis of the results was not feasible.

**Results**

Two independent reviewers conducted an initial survey and identified 624 articles. After reviewing the titles and abstracts (483 removed) and eliminating duplicates (47 removed), 43 articles were selected for full-text review. Following two meetings and discussions on the data, 32 records were evaluated using a methodological quality scale and inclusion/exclusion criteria, of which 11 articles were deemed eligible for this systematic review.

In total, 179 male participants, aged between 19 and 33 years, were evaluated. All selected studies employed a cross-sectional design with randomized practice test arrangements. The studies were published within the last 10 years (between 2013 and December 2022). Moreover, based on the PEDro scale, the studies were classified as having good to excellent quality, as assessed by their methodological reporting process and data.

The exercises most commonly evaluated were knee extension, squat, deadlift, and leg press. In most studies, quadriceps EMG data were normalized using %MVIC, with measurements taken in the prone position with the knee flexed at 90°. The Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) protocol was followed in these studies [13]. Table 1 describes the references, exercises tested, sample size, average age, participant experience, sEMG collection methods, muscle activation levels, and main findings.

Of the selected studies, four examined knee extension exercises [14-17], six focused on variations of the squat exercise [back, goblet, landmine, wall, and Spanish] [18-23], two investigated the leg press [24, 25], and one examined the deadlift [18]. External loads were prescribed as a percentage of 1RM (ranging from 30 to 100% of 1RM) or maximum repetitions (ranging from 6 to 10 RM). Two studies based load on a percentage of body weight [19, 22] (Table 1).

**Figure 2** illustrates the mean normalized %MVIC for the RF, VL, and VM across various exercises. **Table 2** summarizes the average muscle activation levels for each exercise. In general, the leg press elicited the highest %MVIC for the VL and VM, while the Spanish squat demonstrated the highest %MVIC for the RF.

**Vastus Lateralis**

The leg press exercise elicited the highest EMG activity for the VL at 91.34%MVIC, followed by the deadlift at 84.55%MVIC. The goblet squat (76.4%MVIC), knee extension (70.43%MVIC), back squat (67.08%MVIC), and Spanish squat (63%MVIC) also demonstrated exceptionally high muscle activation (>60%MVIC). The landmine squat (59.3%MVIC) and wall squat (47.5%MVIC) elicited high muscle activation (41-60%MVIC).

**Vastus Medialis**

The leg press also demonstrated the highest EMG activity for the VM, reaching 85.08%MVIC. Other exercises with very high activation levels included knee extension (76.80%MVIC), goblet squat (67.8%MVIC), and Spanish squat (63%MVIC). The back squat (58.15%MVIC), landmine squat (55.4%MVIC), and wall squat (51%MVIC) showed high muscle activation levels.

**Rectus Femoris**

The Spanish squat elicited the highest EMG activity for the RF at 91.5%MVIC, followed by knee extension (76.46%MVIC) and leg press (69.5%MVIC), all exhibiting very high muscle activation. The back squat elicited high activation (41.72%MVIC), while the wall squat was the only exercise to achieve moderate activation (29.5%MVIC).

Table1. Description of data extracted from each article regarding reference, Exercises tested, Sample and mean age, Experience, electromyography collection method, target muscles, and main findings.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Main findings** | **Activity sEMG recorded of muscles** | **sEMG collection method** | **Experience** | **Sample (age)** | **Exercises tested** | **Reference** |
| VL activity: traditional> fast =slow–RF activity: fast> traditional =slow –VM activity: fast =traditional=slow | vastus lateralis, vastus medialis and rectus femoris | 3 sets 10RM | 6 months | 12 (24) | leg extension | Antunes, L., et al. 2018[14] |
| No difference was found between exercises | vastus lateralis | 8 sets 2rep 95%RM | 2 years | 10 (24) | squat or deadlift | Barnes, M. J., et al. 2019 [18] |
| IF (internalfocus) < EF (external focus) during the concentric phase | vastus lateralis | 4 reps at 50% or 80% 1-RM sets | 5 years | (27.4) 15 | back-squat | Coratella, G., et al. 2020 [20] |
| heavy > light |  vastus lateralis | 4 set 30% or 80% 1RM | Notindicated | 15 (22) | knee extension | Haun, C. T., et al. 2017 [16] |
| EMG variables were not differentially between groups | vastus lateralis |  1RM 60 deg/s and 120 deg/s | 3 months | 30 (22.15) | barbell back squat | Kephart, W. C., et al. 2016 [21] |
| Significantly greater mean EMG activity during the high-load (HL) set compared to the Low-load (LL) set | vastus medialis, vastus lateralis | 75 % 1RM & 30 % 1RM | 1 year | 10 (21.3) | leg press | Schoenfeld, B. J., et al. 2014 [24] |
| VL activity: leg press > knee extension – RF activity: knee extension > leg press - VM activity: leg press = knee extension | vastus lateralis, vastus medialis, rectus femoris |  1set 6RM | 8.0 ± 5.9 year | 15 (27) | leg press – knee extension | Stien, N., et al. 2021 [25] |
| EMG activity increased in the rectus femoris, vastus lateralis, and vastus medialis for the stretching condition. For the non-stretching condition, activity only increased in the vastus lateralis and medialis. | vastus lateralis, vastus medialis, rectus femoris | 3 set 10RM | 7.5 year | 14 (28.4) | Barbell squat | Trindade, T. B., et al. 2020 [23] |
| the VM and VL showed decreased activity in the LMS compared with the GBS | vastus lateralis, vastus medialis  | 5 rep 30% of their body mass | Notindicated | 16 (23.2) | goblet squat (GBS) - landmine squat (LMS) | Collins et al. 2021 [19] |
| GE (grouped exercises) can promote greater muscle activity of the lower limbs compare to separated exercises (SE) | vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF) | 5 set 8-10 RM | Notindicated | 20 (25.7) | knee extension: [GE] (super set of 1 muscle) or  | Brentano, M. A., et al. 2017 [15] |
| SS shows more activation in the RF and VL muscles compared to GS and WS. | rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM) | 3 times (1 s to reach the nearest position to the floor, held 3s, returned to the original position for 1 s.) | Notindicated | 22 (23) | general squat (GS), wall squat (WS), and Spanish squat (SS) | Lee, J. H., et al. 2022 [22] |

Figure 2. Mean percentage of Maximum Voluntary Isometric Contraction (%MVIC) for rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM) in Leg Press (LP), Deadlift (DL), Goblet Squat (GS), Knee Extension (KE), Back Squat (BS), Spanish Squat (SS), Landmine Squat (LS) and Wall Squat (WS).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mean %MVIC RF** | **Mean %MVIC VM** | **Mean %MVIC VL** | **Number of articles** | **Exercise** |
| 41.72 | 58.15 | 67.08 | 5 | Back Squat |
| 76.46 | 76.80 | 70.43 | 4 | Knee Extension |
| 69.5 | 85.08 | 91.34 | 2 | Leg Press |
| 91.5 | 63 | 63 | 1 | Spanish Squat |
| 29.5 | 51 | 47.5 | 1 | Wall Squat |
| - | 67.8 | 76.4 | 1 | Goblet Squat |
| - | 55.4 | 59.3 | 1 | Landmine Squat |
| - | - | 84.55 | 1 | Deadlift |

Table2. Pooled mean summary of mean percentage of maximal voluntary isometric contraction (%MVIC) for quadriceps in different exercises.

**Discussion**

This systematic review aimed to assess the EMG activity of the quadriceps femoris muscles in healthy adult males during common strength exercises. The review revealed that the VL was the most frequently studied quadriceps muscle across various exercises. The main findings indicated that the leg press exercise produced the highest VL and VM activation, while the Spanish squat was most effective for RF activation.

*Vastus Lateralis*

For the VL, the leg press elicited the highest EMG activity (91.34%MVIC), followed closely by the deadlift (84.55%MVIC). Similar findings were reported by Martín-Fuentes et al. (2020), who observed greater VL activation compared to other muscles [11]. This increased activation could be attributed to the greater isokinetic strength of the VL at the end range of motion [26].

**Vastus Medialis**

The leg press also demonstrated the highest EMG activity for the VM (85.08%MVIC). Contrary to Stien, N. et al. (2020) findings, the leg press showed higher EMG activity than the knee extension exercise for the VM. While the GS and SS elicited similar EMG activity for the VM, the SS is relatively more difficult due to its demand for proper torso-pelvis alignment and knee joint positioning. Consequently, the GS may be more suitable for beginners and intermediate-level individuals.

**Rectus Femoris**

The RF was the least studied muscle compared to the VL and VM, and the SS elicited the highest %MVIC for the RF (91.5%). This is likely due to the more upright torso relative to the hips during the SS, increasing RF activation. The RF during the wall squat (WS) was the only instance of moderate %MVIC in this review.

**Limitations**

 A fundamental limitation of this review is the inconsistency in the methods used to measure EMG activity, which raises concerns about the interpretation of results and potential bias. Future research should aim to reduce these methodological differences to improve the comparability of findings [27]. Additionally, the current literature focuses exclusively on healthy adult males. Whether similar muscle activation patterns would be observed in injured athletes or women remains unclear. Furthermore, variations in load (ranging from 30% to 100% RM) or differences in training experience and familiarity with the exercises may impact quadriceps activation [28].

**Conclusion**

 Coaches, athletic trainers, and physical therapists can use the findings of this systematic review to categorize various exercises by the level of quadriceps activation, ranging from low to high. This information can aid in developing progressive training programs to enhance quadriceps strength and improve overall athletic performance.

The main findings of this systematic review are as follows:

1. The VL was the most studied quadriceps muscle during common strength exercises.
2. The leg press elicited the highest EMG activity for the VL and VM, while the SS demonstrated the highest EMG activity for the RF.
3. Standardizing participants’ resistance training experience, sEMG collection methods and electrode placement are essential for obtaining conclusive outcomes.

**Reverences**

1. Maestroni L, Read P, Bishop C, Papadopoulos K, Suchomel TJ, Comfort P, et al. The Benefits of Strength Training on Musculoskeletal System Health: Practical Applications for Interdisciplinary Care. J Sports Med. 2020;50(8):1431-50.

2. Bennie JA, Shakespear-Druery J, De Cocker K. Muscle-strengthening Exercise Epidemiology: a New Frontier in Chronic Disease Prevention. Sports Med - Open. 2020;6(1):40.

3. Fragala MS, Cadore EL, Dorgo S, Izquierdo M, Kraemer WJ, Peterson MD, et al. Resistance Training for Older Adults: Position Statement From the National Strength and Conditioning Association. J Strength Cond Res. 2019;33(8).

4. Ramari C, Hvid LG, David ACd, Dalgas U. The importance of lower-extremity muscle strength for lower-limb functional capacity in multiple sclerosis: Systematic review. Ann Phys Rehabil Med. 2020;63(2):123-37.

5. Garhammer J. Weight lifting and training. In: Vaughan CL, editor. Biomechanics of sport. Boca Raton: CRC Press; 2020. p. 169-211.

6. Migliaccio GM, Dello Iacono A, Ardigò LP, Samozino P, Iuliano E, Grgantov Z, et al. Leg Press vs. Smith Machine: Quadriceps Activation and Overall Perceived Effort Profiles. Front physiol. 2018;9.

7. Martín-Fuentes I, Oliva-Lozano JM, Muyor JM. Evaluation of the Lower Limb Muscles’ Electromyographic Activity during the Leg Press Exercise and Its Variants: A Systematic Review. Int J Environ Res Public Health [Internet]. 2020; 17(13).

8. Xiong D, Zhang D, Zhao X, Zhao Y. Deep Learning for EMG-based Human-Machine Interaction: A Review. IEEE/CAA J Autom Sin. 2021;8(3):512-33.

9. Shayesteh M, Farahpour N, Jafarnezhadgero A. Comparisons of The Effects of Squat and Leg ‌Press Exercises on The EMG Activity of Quadriceps Femoris Muscles During Step Descending Activity. Int J Appl Exerc Physiol. 2019;15(29):143-54.

10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Int J Surg. 2010;8(5):336-41.

11. Martín-Fuentes I, Oliva-Lozano JM, Muyor JM. Electromyographic activity in deadlift exercise and its variants. A systematic review. PLOS ONE. 2020;15(2):e0229507.

12. Macadam P, Feser EH. EXAMINATION OF GLUTEUS MAXIMUS ELECTROMYOGRAPHIC EXCITATION ASSOCIATED WITH DYNAMIC HIP EXTENSION DURING BODY WEIGHT EXERCISE: A SYSTEMATIC REVIEW. Int J Sports Phys Ther. 2019;14(1):14-31.

13. Hermens HJ, Freriks B, Disselhorst-Klug C, Rau G. Development of recommendations for SEMG sensors and sensor placement procedures. J Electromyogr Kinesiol. 2000;10(5):361-74.

14. Antunes L, Bezerra EdS, Sakugawa RL, Dal Pupo J. Effect of cadence on volume and myoelectric activity during agonist-antagonist paired sets (supersets) in the lower body. Sports Biomech. 2018;17(4):502-.

15. Brentano MA, Umpierre D, Santos LP, Lopes AL, Radaelli R, Pinto RS, et al. Muscle Damage and Muscle Activity Induced by Strength Training Super-Sets in Physically Active Men. J Strength Cond Res. 2017;31(7).

16. Haun CT, Mumford PW, Roberson PA, Romero MA, Mobley CB, Kephart WC, et al. Molecular, neuromuscular, and recovery responses to light versus heavy resistance exercise in young men. Physiol Rep. 2017;5(18):e13457.

17. Stien N, Pedersen H, Ravnøy AH, Andersen V, Saeterbakken AH. Training specificity performing single-joint vs. multi-joint resistance exercises among physically active females: A randomized controlled trial. PLOS ONE. 2020;15(5):e0233540.

18. Barnes MJ, Miller A, Reeve D, Stewart RJC. Acute Neuromuscular and Endocrine Responses to Two Different Compound Exercises: Squat vs. Deadlift. J Strength Cond Res. 2019;33(9).

19. Collins KS, Klawitter LA, Waldera RW, Mahoney SJ, Christensen BK. Differences in Muscle Activity and Kinetics Between the Goblet Squat and Landmine Squat in Men and Women. J Strength Cond Res. 2021;35(10).

20. Coratella G, Tornatore G, Longo S, Borrelli M, Doria C, Esposito F, et al. The Effects of Verbal Instructions on Lower Limb Muscles’ Excitation in Back-Squat. Res Q Exerc Sport. 2022;93(2):429-35.

21. Kephart WC, Mumford PW, McCloskey AE, Holland AM, Shake JJ, Mobley CB, et al. Post-exercise branched chain amino acid supplementation does not affect recovery markers following three consecutive high intensity resistance training bouts compared to carbohydrate supplementation. J Int Soc Sports Nutr. 2016;13(1):30.

22. Lee J-H, Kim S, Heo J, Park D-H, Chang E. Differences in the muscle activities of the quadriceps femoris and hamstrings while performing various squat exercises. BMC sports sci, med rehabil. 2022;14(1):12.

23. Trindade TB, Neto LO, Pita JCN, Tavares VDdO, Dantas PMS, Schoenfeld BJ, et al. Pre-stretching of the Hamstrings Before Squatting Acutely Increases Biceps Femoris Thickness Without Impairing Exercise Performance. Front physiol. 2020;11.

24. Schoenfeld BJ, Contreras B, Willardson JM, Fontana F, Tiryaki-Sonmez G. Muscle activation during low- versus high-load resistance training in well-trained men. Eur J Appl Physiol. 2014;114(12):2491-7.

25. Stien N, Saeterbakken AH, Andersen V. Electromyographic Comparison of Five Lower-Limb Muscles between Single- and Multi-Joint Exercises among Trained Men. J Sports Sci Med. 2021;20(1):56-61.

26. Alegre LM, Ferri-Morales A, Rodriguez-Casares R, Aguado X. Effects of isometric training on the knee extensor moment–angle relationship and vastus lateralis muscle architecture. Eur J Appl Physiol. 2014;114:2437–46.

27. Llurda-Almuzara L, Labata-Lezaun N, López-de-Celis C, Aiguadé-Aiguadé R, Romaní-Sánchez S, Rodríguez-Sanz J, et al. Biceps Femoris Activation during Hamstring Strength Exercises: A Systematic Review. Int J Environ Res Public Health [Internet]. 2021; 18(16).

28. Neto WK, Soares EG, Vieira TL, Aguiar R, Chola TA, Sampaio VL, et al. Gluteus Maximus Activation during Common Strength and Hypertrophy Exercises: A Systematic Review. J Sports Sci Med. 2020;19(1):195-203.