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Electromyography Activity of Biceps and Triceps Muscle in Concentration Curl and Kickback Exercise among Young Healthy Individual

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Abstract

Electromyography is a valuable tool for assessing muscle function and neuromuscular performance by capturing electrical signals generated during muscle fibre activation. Surface electromyography offers a non-invasive method of recording muscle activity, which plays a crucial role in analysing muscle behaviour during movement. This study investigated and compared peak muscle activation patterns between agonist and antagonist muscles during two resistance exercises: concentration curls and kickbacks. Fifty healthy adults aged 20 to 30 years participated in the study, selected based on specific inclusion and exclusion criteria. Participants were divided into two groups and performed the exercises while muscle activity was recorded using surface electrodes placed on the targeted muscles. Data were analysed using independent t-tests and Wilcoxon rank sum tests to assess differences in peak activation across exercises and muscle groups. Results indicated a noticeable difference in peak activation levels between the agonist and antagonist muscles during both exercises. The biceps muscle exhibited higher peak activation than the triceps, regardless of whether it functioned as an agonist or antagonist. These findings highlight the influence of exercise type on muscle recruitment patterns, which has implications for designing effective strength training and rehabilitation protocols.

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1. Introduction

Electromyography (EMG) is a widely utilized technique for assessing muscle activation and neuromuscular function during physical activity, particularly effective in understanding the functional behaviour of agonist and antagonist muscle groups during resistance exercises [1-3]. Surface EMG (SEMG), a non-invasive method, provides valuable insights into the recruitment patterns of superficial muscles by detecting electrical signals generated during muscle contractions [2, 4].

Resistance training exercises like concentration curls and triceps kickbacks are commonly employed to isolate and strengthen the biceps brachii and triceps brachii muscles, respectively [5-8]

These exercises target upper limb musculature and are widely incorporated into athletic training, rehabilitation, and fitness programs [9, 10]. Understanding the activation patterns of these muscles during such exercises can significantly enhance the effectiveness of training protocols and assist in rehabilitation strategies [11, 12]. Previous studies have established the relevance of SEMG in analysing muscle performance under various exercise conditions [13, 14]. However, comparative data on biceps and triceps muscle activation during single-joint isotonic exercises such as concentration curls and kickbacks in healthy individuals remains limited.

This study aims to bridge the existing gap by evaluating and comparing peak muscle activation of biceps (as the agonist) and triceps (as the antagonist), and vice versa, during two specific exercises. The findings may contribute to optimizing resistance training techniques and support clinical decision making in musculoskeletal rehabilitation.

Methodology

1.1. Study Design

This experimental study aimed to assess electromyographic (EMG) activity in the biceps brachii and triceps brachii during two resistance exercises concentration curls and triceps kickbacks. It was conducted at the Department of Physiotherapy, Sardar Bhagwan Singh University Post Graduate Institute of Biomedical Sciences and Research, Balawala, Dehradun, over a duration of one year.

1.2. Participants

The selected sample size of 50 participants (25 per group) was informed by sample size ranges used in comparable electromyography (EMG) studies in the field of physiotherapy. Prior research has demonstrated that a minimum of 20–30 subjects per group is adequate for detecting moderate to large effect sizes (Cohen's d ≈ 0.5–0.8) in EMG amplitude analysis with statistical power above 0.80 at a significance level of 0.05.2, 4 Specifically, Young (2009) conducted EMG-based assessments of upper limb muscles with similar group sizes, validating this approach. While no formal a priori power calculation was performed, the statistically significant results obtained in our study suggest that the sample was sufficient to detect meaningful intergroup differences in muscle activation patterns.8 Future research may benefit from larger samples and formal power modelling to enhance generalizability and detect smaller effect sizes.

A total of 50 healthy student volunteers (25 males and 25 females) aged between 20 and 30 years (mean age: 25 years) took part in the study. Subjects were randomly selected from the university population. Participants included individuals with a BMI between 18 and 25.5, considered healthy, and without any history of illness, injury, or surgery. Participants were excluded if they had recent infections, trauma, poor physical fitness, or any functional impairments. All participants were right-hand dominant. Ethical clearance was obtained from the Institutional Ethics Committee of Sardar Bhagwan Singh University, Dehradun. Approval Reference No.: SBS/PHYSIO/25002/25, and informed consent was secured prior to participation.

1.3. Instrumentation

The study employed surface EMG (sEMG) to measure muscle activity. Equipment included as shown in the figure 1 and 2:

- EMG machine and adhesive surface electrodes
- Dumbbells of various weights
- Measurement tape and weighing machine
- Stadiometer

Reliability of sEMG recordings was evaluated using the intraclass correlation coefficient (ICC), standard error of measurement (SEM), and minimal detectable change (MDC). ICC values were interpreted as follows: ≥0.80 = excellent, 0.60–0.79 = good, and <0.60 = poor. A 95% confidence interval was applied to all statistical analyses.

1.4. Electrode Placement and Preparation

Skin preparation included cleansing with alcohol and shaving if necessary. Electrodes were applied to the dominant (right) arm, with careful placement to ensure accurate signal acquisition and minimize artefacts.

- **Biceps Brachii (BB):** Electrodes were placed vertically along the anterior surface of the humerus, approximately two-thirds of the way from shoulder to elbow, aligned with the muscle fibers.
- **Triceps Brachii (TB):** Electrode placement targeted the posterolateral upper arm, halfway between the acromion and olecranon, with specific configurations for both the long and lateral triceps heads.

1.5. Procedures

Participants refrained from vigorous physical activity for 48 hours prior to testing. Sessions began with a 5-minute aerobic warm-up and dynamic stretching, followed by a familiarization session with the exercises and equipment.

Electromyographic activity was recorded during the performance of two exercises

- **Group A:** Concentration Curl Participants sat on a stool with their elbow supported against their inner thigh. Holding a dumbbell with a supinated grip, they performed elbow flexion to shoulder height and returned to the extended position as shown in the figure 3.
- **Group B:** Triceps Kickback Participants bent forward with a neutral spine, holding the dumbbell with palms facing inward. The forearm was extended backward until the elbow was locked and then returned to the starting position as shown in the figure 4.

Each exercise was performed for five repetitions. Throughout, participants were guided to maintain correct posture and motion range, ensuring data consistency.

Fig 1: Equipment EMG Machine, Adhesive Surface Electrode, Dumbbell, Measurement tape, Weighing machine.

Fig 2: Stadiometer

Fig 3: Subject performing concentration curl exercise

Fig 4: Subject performing kickback exercise

2. Data Analysis and Results

Data analysis was performed using IBM SPSS Statistics version 23. An independent samples t-test was used to compare agonist and antagonist muscle activation between Group A (concentration curl) and Group B (kickback). Statistical significance was set at $p < 0.05$ with a 95% confidence interval. To further confirm differences in muscle activation patterns, the non-parametric Wilcoxon rank sum test was also applied.

2.1. Participant Demographics

A total of 50 participants were enrolled, with 25 in each exercise group. Both groups had an equal distribution of males and females. The mean age was consistent across groups. Table 1 and Figure 5 presents participant characteristics by group and sex.

Table 1: Demographic characteristics of participants.

Variable	Group A: Concentration Curl (n = 25)	Group B: Kickback (n = 25)	Total (n = 50)
Male, n (%)	13 (52%)	12 (48%)	25 (50%)
Female, n (%)	12 (48%)	13 (52%)	25 (50%)
Mean age (years) ± SD	24.22 ± 2.09	24.22 ± 2.09	24.22 ± 2.09

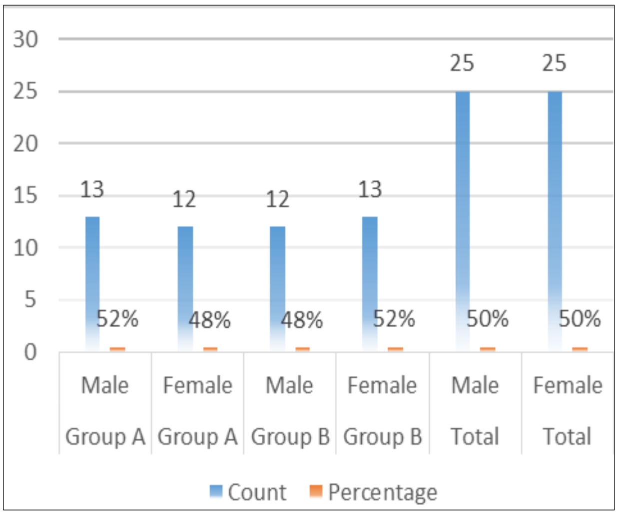

Fig 5: Demographic characteristics of participants.

No meaningful differences in age or sex distribution were observed between groups, ensuring comparability.

2.2. Muscle Activation Results

EMG activity for agonist and antagonist muscles was recorded during each exercise. The biceps brachii acted as the agonist during the concentration curl and the antagonist during the kickback; the reverse was true for the triceps brachii.

Group A (Concentration Curl) showed higher mean biceps activation (agonist role) compared to Group B (Kickback). In contrast, the triceps muscle (as antagonist) showed higher activation during the kickback than in the concentration curl. These observations are summarized in Table 2 to Figure 6.

Table 2: Muscle activation values (mean ± SD, in µV) by exercise group.

Muscle Role	Group A: Curl (n = 25)	Group B: Kickback (n = 25)
Biceps – Agonist	1200.48 ± 529.98	760.12 ± 446.14
Triceps – Antagonist	547.98 ± 348.09	1227.24 ± 406.61

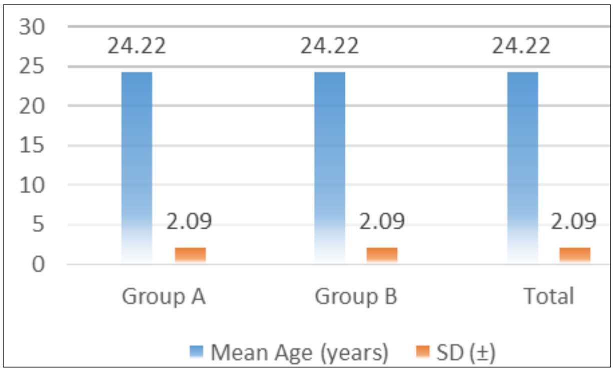

Fig 6: Muscle activation values (mean ± SD, in µV) by exercise group.

2.3. Statistical Comparison of Activation

Muscle activation values were compared using group-wise t-tests and Wilcoxon rank tests. These comparisons confirmed that muscle engagement differed depending on the exercise type. Table 3 highlights the group mean ranks and Table 4 displays t-test values.

Table 3: Wilcoxon rank analysis of muscle activity.

Condition	Group	Mean Rank	Wilcoxon W	Z-value	p-value
Agonist	Curl	63.22	1889.00	-4.387	<0.01
	Kickback	37.78	—	—	—
Antagonist	Curl	30.34	1517.00	-6.949	<0.01
	Kickback	70.66	—	—	—

Both sets of comparisons indicated statistically relevant differences in activation between exercise types for both muscle roles.

2.4. Peak Torque Comparison

Additional analysis of peak torque values demonstrated distinct differences between exercises. Each muscle generated higher force output when acting as the primary mover in its corresponding exercise. Table 4 summarizes the peak torque differences.

Table 4: Peak torque t-test comparison between groups

Exercise Group	Muscle Role	t-value	p-value
Curl	Agonist (Biceps)	2.718	0.009
	Antagonist	2.648	0.011
Kickback	Agonist (Triceps)	4.191	<0.01
	Antagonist	6.551	<0.01

The biceps showed the highest EMG activity (1200.48 µV) during concentration curls when acting as the agonist. The triceps showed the highest activity (1227.24 µV) during kickbacks, also in the agonist role. Muscle activity in antagonistic roles was always lower than in agonist roles, but still measurable suggesting co-contraction and stabilization demands

3. Discussion

This study evaluated surface electromyographic (sEMG) activity of the biceps and triceps muscles during concentration curl and kickback exercises, identifying significant differences in muscle activation between these movements. The biceps showed notably higher activation during concentration curls, while the triceps were more engaged during kickbacks, confirming that each exercise selectively targets its intended muscle group.

Previous studies have established the reliability of sEMG in capturing muscle activation patterns during dynamic resistance exercises. [1–3] Surface electrodes provide a non-invasive means to assess muscle fibre recruitment, offering precise insights into agonist-antagonist behaviour under load [1, 2]. The observed results align with prior analyses that confirmed distinct muscle engagement patterns during isolated joint exercises, supporting sEMG's validity in both research and clinical applications [3, 4].

Research evaluating resistance exercises has identified the concentration curl as among the most effective for biceps activation, while the kickback has been validated for triceps isolation [5, 6]. These findings are consistent with the biomechanical principles of muscle alignment, joint position, and lever arm advantage, which influence neuromuscular recruitment [7]. Seated and bent-arm postures in these exercises help isolate the target muscle by minimizing synergistic contributions, thereby enhancing the specificity of activation [8].

In rehabilitation and conditioning settings, isolated strengthening movements like these are commonly prescribed to restore function and build targeted muscle strength [9]. Muscle hypertrophy is known to be influenced by factors such as mechanical tension and neuromuscular engagement both of which are indirectly measured through EMG amplitude [10]. Findings from this study indicate that peak activation data can serve as a valuable tool for clinicians and trainers in selecting exercises to enhance program effectiveness.

Beyond strength training, EMG assessment plays a critical role in evaluating fatigue and neuromuscular performance. Studies have used EMG to monitor overload, identify asymmetries, and evaluate therapy outcomes across various populations [11, 12]. This study contributes to that field by demonstrating how specific exercises influence muscle activity in a predictable, measurable way.

Other research has shown that sEMG amplitude correlates with muscle force and can inform real-time prosthetic control or assistive technology [13], The methodological consistency of this study further supports EMG's utility in applications beyond sports science, including neurology and robotics. High reliability of this technique has been demonstrated even across different examiners, reinforcing its reproducibility in clinical settings [15].

Some evidence suggests that antagonist muscles may display co-activation or involuntary engagement during agonist-driven tasks, potentially to stabilize the joint or enhance proprioception [14]. This could explain the measurable but lower triceps activation observed during biceps-dominant exercises, and vice versa.

Muscle recruitment patterns may vary by demographic factors. For example, sex-based differences in upper-body strength and fatigue response have been observed in resistance training contexts, with some findings suggesting females may experience greater activation or stress under similar conditions [16]. Although the present study included equal numbers of male and female participants, sex-specific EMG differences were not analysed and should be explored in future research. Anatomical factors such as carrying angle also influence medial versus lateral muscle activation patterns during upper-arm movements, [17] and these biomechanical differences could affect EMG output across individuals.

Additionally, mechanical interventions like localized vibration have been shown to enhance co-activation and neuromuscular efficiency during isometric contractions, [18] possibly contributing to stabilizing muscle activity even when not intentionally recruited. Co-activation patterns in antagonist muscles also vary by contraction type and frequency domain characteristics, emphasizing the need for dynamic rather than purely amplitude-based interpretation of EMG signals [19].

Other studies have explored fatigue detection using EMG signal features during high-repetition training protocols. For example, machine learning models have been used to classify biceps fatigue with high accuracy using EMG-derived features [20]. Although our study did not focus on fatigue analysis, its standardized repetitions and consistent EMG patterns lay a foundation for future algorithm-based fatigue detection models.

Finally, the role of individual muscle heads in complex muscle groups like the triceps has been highlighted in prior research. Differences in activation among the lateral, long, and medial heads under varying intensities and speeds show that muscle recruitment is not only exercise-specific but also dependent on internal force distribution within a muscle group [21]. Although the present study measured whole-muscle activity, head-specific EMG may reveal even finer details in future research.

4. Conclusion

This study demonstrated significant differences in electromyographic (EMG) peak muscle activation between biceps and triceps during concentration curl and kickback exercises among healthy young adults. Specifically, the biceps brachii showed higher peak activation in both agonist and antagonist roles, suggesting greater neuromuscular engagement compared to the triceps brachii. These findings highlight the influence of exercise type on muscle recruitment patterns, possibly explained by biomechanical positioning and muscle leverage during movement.

A novel aspect of this study is its direct comparison of agonist and antagonist muscle roles within two commonly used resistance exercises using surface EMG, providing practical implications for designing more effective strength training and rehabilitation protocols. The observed muscle-specific activation patterns underscore the need to tailor exercise selection based on targeted muscular engagement, which is especially relevant in clinical rehabilitation and athletic training settings.

However, the study was limited by the lack of EMG graph printouts for visual data interpretation and challenges in controlling posture and external interference during data acquisition. Additionally, the sample was limited to young, healthy individuals, potentially reducing generalizability to older or clinical populations.

Future research should include larger and more diverse populations, consider sex and gender influences in muscle activation patterns, and explore the utility of multi-channel EMG systems for richer data insights. Clinically, these findings may aid practitioners in selecting exercises that maximize desired muscle recruitment, while policymakers in physical therapy education and sports training could benefit from evidence-based integration of EMG-informed protocols.

5. Ethical Consideration

The study was conducted in accordance with the ethical standards outlined by the Institutional Ethics Committee of Sardar Bhagwan Singh University, Dehradun. Ethical approval was obtained prior to data collection under approval reference number SBS/PHYSIO/25002/25. All participants provided written informed consent before their inclusion in the study. Confidentiality of the participants was maintained throughout the research process, and participation was entirely voluntary, with the option to withdraw at any time without any consequences.

6. Conflict of Interest

The authors declare that there are no conflicts of interest related to this study. No financial, professional, or personal relationships have influenced the design, conduct, analysis, or reporting of the research presented in this manuscript.

7. Acknowledgement

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