RESEARCH PAPER

The Effect of Maximal Voluntary Isometric Contractions on Muscle Activity in Upper Limb Kinetic Chains

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ABSTRACT

Introduction: Myofascial chains are proposed to facilitate force transmission between anatomically connected muscles. However, functional electromyographic correlations within upper-limb kinetic chains remain insufficiently characterized. Aim of study. To investigate whether myoelectrical connections exist between upper-limb muscles, those are anatomically linked by myofascial pathways.

Methods: A cross-sectional correlational study was conducted on 40 healthy adults (18–30 years). Surface electromyography (EMG) recorded activity of the upper trapezius, latissimus dorsi, and pectoralis major during maximal voluntary isometric contractions (MVIC) of extensor carpi radialis brevis (ECRB), extensor carpi ulnaris (ECU), and flexor carpi radialis (FCR). Spearman correlation coefficients were calculated.

Results: Only During FCR MVIC, a moderate positive correlation was observed between the upper trapezius and pectoralis major ($r = 0.339$, $p = 0.03$). All other correlations were weak and non-significant During ECRB and ECU contractions, ($p > 0.05$).

Conclusion: Findings suggest limited and task- specific intermuscular coupling within proposed upper limb myofascial chains overall anatomical continuity doesn't necessary translate in two strong functional EMG synchronizations.

Keywords: Kinetic chains; Myofascial connections; Electromyography; Upper limb; Muscle activation

How to cite this article: Sayed MA, Abdelmegid SF, Abdelkader B, El-Khozamy HM. The Effect of Maximal Voluntary Isometric Contractions on Muscle Activity in Upper Limb Kinetic Chains. Int J Drug Deliv Technol. 2026;16(29s):69-74. DOI: 10.25258/ijddt.16.29s.9

Source of support: None

Conflict of interest: None

INTRODUCTION

The human body is a complex system of interdependent structure and function rather than just isolated components. Myofascial chains—functional fibers of connective tissue (fascia) that wind through and link muscles, bones, nerves, and organs throughout the body [1]. These chains are necessary for the smooth, strong, and precise actions we do on a daily basis in the upper limb, such as reaching, gripping, pushing, and throwing [2].

Every muscle fiber, muscle, muscle group, bone, and organ is surrounded and penetrated by the continuous, three-dimensional network of collagenous connective tissue known as fascia [3]. Within this network, a myofascial chain is a pre-tensioned channel that disperses movement, force, and strain throughout the body. These chains enable coordinated, effective movement patterns as compared to a single muscle working alone [4].

Based on anatomical dissection, Wilke et al. (2015) identified morphologically connected muscle fascia routes in the shoulder-arm area, three continuous muscle-fascia lines (ventral, dorsal, and lateral) extend between the shoulder and forearm regions [5].

Martin et al. (2013) reported the association of muscle activations along the superficial back line (SBL) under active (with – without) resistance and passive movement supporting the concept of fascial force transmission and regional in depended, dysfunction in any muscle along any kinetic chain might change overall activation patterns [6].

The entire fascial chain becomes tense as a result of contraction, not simply the bone to which it is linked [7]. Tightening grip (finger flexors) can slightly increase tension in the forearm, over the elbow, and into the shoulder and chest, for example. Because of this, a strong tennis swing starts in the legs and core and is effectively transmitted to the racket via the arm chain [8].

In addition, deltoid activation during arm elevation fascial connections facilitates coordinate recruitment of opposing latissimus dorsi for trunk stability and the serratus anterior for scapular rotation. If one link in the chain is weak or inhibited, compensatory activation may occur elsewhere in the chain [9].

Areas not intended to support the major load may experience overuse and strain as a result [10]. For example,

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shoulder impingement may result from the scapula and rotator cuff overworking due to a rigid thoracic spine [11].

Overhead shoulder mobility can be increased by releasing the latissimus dorsi as a part of dorsal chain. The scapula and arm can move freely after the release, which causes the entire chain to lengthen [12]. The muscles in the chain may stretch and glide more smoothly when fascial tension is adjusted through release (such as massage, foam rolling, and myofascial release). This enhances strength and coordination by reducing the energy needed for movement and allowing more efficient muscle firing patterns [13].

There was a lack of standard normative data on upper limb kinetic chains and correlation between muscles of upper limb [5].

While previous research has examined fascial anatomy and its biomechanical implications, the functional correlations of muscular activity within upper-limb myofascial chains remain poorly characterized.

There for this study aimed to examine intermuscular EMG correlations among selected upper limb and shoulder girdle muscles during rest MVIC tasks as afunctional test of proposed myofascial chains connectivity.

SUBJECTS AND METHODS:

Study Design: Cross-sectional correlational study was conducted at kasralainy neurophysiology clinic. The research was conducted over a period of 6 months from December 2024 to June 2025.

Participants: Forty healthy adults were recruited. Inclusion criteria included aged 18–30 years both sex and BMI 18:25 with regular physical activity 5:10 h /week [6]. Exclusion criteria included chronic upper-limb pain more than 3 months, smoking, pacemaker implantation, or use of muscle relaxants [6] and neurological disorder in upper limb (nerve injury, radiculopathy or upper motor lesion as hemiplegia or ataxia) [14].

Procedure:

Surface EMG electrodes (Figure 1) were placed over every muscle; the active electrode placed over the muscle belly to be measured according to standardized anatomical land marks (upper fibers of the trapezius, latissimus dorsi, and pectoralis major), and reference electrode was placed on the same muscle fiber direction away 1-2 cm. while ground electrode placed on a bony area to reduce noise. Before began skin was prepared to reduce impedance. The subject was instructed to sit and relax. All researchers received training on the appropriate electrode placements and anatomical landmarks. Two researchers were present for each testing session, and every trial was attempted to accurately duplicate the electrode sites. (Figure 2) via anatomical landmarks

The experimental protocol included three different test conditions each session lasted approximately 30 minutes participant were instructed and allowed a practice for each condition. Before each maximal voluntary contraction participants relaxed for 5:10 s to establish a baseline if a stable baseline couldn`t be obtained. The trial was repeated after took arest.

FCR condition; the participants performed wrist flexion combined with radial deviation against manual resistance while maintaining an isometric contraction (FCR maximal voluntary contraction).

ECRB condition; the participants performed wrist extension combined with radial deviation against manual resistance while maintaining an isometric contraction (ECRB maximal voluntary contraction).

ECU condition: the participants performed wrist extension combined with ulnar deviation against manual resistance while maintaining an isometric contraction (ECU condition maximal voluntary contraction).

Subjects were asked to do maximal isometric contraction in the three conditions to obtain a good, steady EMG signal for data processing and analysis; three trials of each exercise were being performed, separated by 2-min rest periods between trials for each of the muscles tested, and then an average value has been calculated. EMG data for each muscle will be integrated, and the maximum root mean square activity, number of turns and amplitude would be calculated for each trial.

Statistical analysis:

Descriptive statistics were utilized in presenting the subjects demographic. Spearman rank correlation coefficient was conducted to investigate the correlation between amplitude of trapezius, latissimus dorsi and pectoralis. The level of significance for statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

RESULTS

Subjects' characteristics:

The mean ± SD age, weight, height and BMI of subjects were 23.30 ± 3.20 years, 66.90 ± 9.62 kg, 163.30 ± 6.15 cm and 25.08 ± 3.27 kg/m². subject characteristics is presented in table (1).

Table 1: Subjects characteristics.

	Mean ± SD	**Maximum**	**Minimum**
Age (years)	23.30 ± 3.20	30	19
Weight (kg)	66.90 ± 9.62	90	50
Height (cm)	163.30 ± 6.15	178	153
BMI (kg/m²)	25.08 ± 3.27	31.25	19.05
Sex, N (%)	**N**	**%**	
Females	17	(42.5%)	
Males	23	(57.5%)	

SD, Standard deviation

- Correlation between amplitude of trapezius, latissimus dorsi and pectoralis during MVICs:

During ECRB MVIC, weak non-significant correlations were found between trapezius and latissimus dorsi (r = -0.082, p = 0.616), trapezius and pectoralis major (r = 0.075, p = 0.646), and pectoralis major and latissimus dorsi (r = 0.172, p = 0.290).

During FCR MVIC, trapezius showed a weak negative, non-significant correlation with latissimus dorsi (r = -0.011, p = 0.946) but a moderate positive, significant correlation with pectoralis major (r = 0.339, p = 0.03). The correlation between pectoralis major and latissimus dorsi was weak negative and non-significant (r = -0.109, p = 0.504).

During ECU MVIC, all correlations were weak and non-significant: trapezius and latissimus dorsi (r = 0.039, p = 0.809), trapezius and pectoralis major (r = -0.105, p = 0.519), and pectoralis major and latissimus dorsi (r = 0.168, p = 0.299). (Table 2).

Table 2. Correlation between amplitude of trapezius, latissimus dorsi and pectoralis major during MVIC of ECRB, FCR and ECU:

		Latissimus dorsi		Pectoralis major	
		r value	**p value**	**r value**	**p value**
ECRB	**Trapezius**	-0.082	0.616	0.075	0.646
	Pectoralis major	0.172	0.290		
FCR	**Trapezius**	-0.011	0.946	0.339	0.03
	Pectoralis major	-0.109	0.504		
ECU	**Trapezius**	0.039	0.809	-0.105	0.519
	Pectoralis major	0.168	0.299		

*r value: Spearman rank correlation; p value: Probability value, * significant at p < 0.05.*

Table 3. Comparison of amplitude of trapezius, latissimus dorsi and pectoralis major during ECRB maximum isometric contraction.

<table>
<tr><th colspan="3">Amplitude during ECRB maximum isometric contraction (mV)</th><th rowspan="3">Kruskal-Wallis H</th><th rowspan="3">p- value</th><th rowspan="3">Sig</th></tr>
<tr><th colspan="3">Median (IQR)</th></tr>
<tr><th>Trapezius</th><th>Latissimus dorsi</th><th>Pectoralis major</th></tr>
<tr><td>187.50 (254.50, 158.75)</td><td>0 (0, 0)</td><td>134 (175, 0)</td><td>68.31</td><td>0.001</td><td>S</td></tr>
<tr><th colspan="6">Mann-Whitney test</th></tr>
<tr><th colspan="2"></th><th>U- value</th><th colspan="2">p- value</th><th>Sig</th></tr>
<tr><th colspan="2">Trapezius - Latissimus dorsi</th><td>33</td><td colspan="2">0.001</td><td>S</td></tr>
<tr><th colspan="2">Trapezius - Pectoralis major</th><td>351</td><td colspan="2">0.001</td><td>S</td></tr>
<tr><th colspan="2">Latissimus dorsi - Pectoralis major</th><td>319</td><td colspan="2">0.001</td><td>S</td></tr>
</table>

IQR: interquartile range; p-value: probability value; S: significant; U-value: Mann-Whitney test value

Table 4. Comparison of amplitude of trapezius, latissimus dorsi and pectoralis major during ECRB maximum isometric contraction.

<table>
<tr><th colspan="3">Amplitude during ECRB maximum isometric contraction (mV)</th><th rowspan="3">Kruskal-Wallis H</th><th rowspan="3">p- value</th><th rowspan="3">Sig</th></tr>
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<tr><th colspan="2"></th><th>U- value</th><th colspan="2">p- value</th><th>Sig</th></tr>
<tr><th colspan="2">Trapezius - Latissimus dorsi</th><td>33</td><td colspan="2">0.001</td><td>S</td></tr>
<tr><th colspan="2">Trapezius - Pectoralis major</th><td>351</td><td colspan="2">0.001</td><td>S</td></tr>
<tr><th colspan="2">Latissimus dorsi - Pectoralis major</th><td>319</td><td colspan="2">0.001</td><td>S</td></tr>
</table>

IQR: interquartile range; p-value: probability value; S: significant; U-value: Mann-Whitney test value

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Table 5. Comparison of amplitude of trapezius, latissimus dorsi and pectoralis major during ECRB maximum isometric contraction.

<table>
<tr><th colspan="3">Amplitude during ECRB maximum isometric contraction (mV)</th><th rowspan="3">Kruskal-Wallis H</th><th rowspan="3">p-value</th><th rowspan="3">Sig</th></tr>
<tr><th colspan="3">Median (IQR)</th></tr>
<tr><th>Trapezius</th><th>Latissimus dorsi</th><th>Pectoralis major</th></tr>
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<tr><th>Trapezius - Latissimus dorsi</th><td>33</td><td>0.001</td><td>S</td></tr>
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<tr><th>Latissimus dorsi - Pectoralis major</th><td>319</td><td>0.001</td><td>S</td></tr>
</table>

IQR: interquartile range; p-value: probability value; S: significant; U-value: Mann-Whitney test value

Figure 1. EMG device

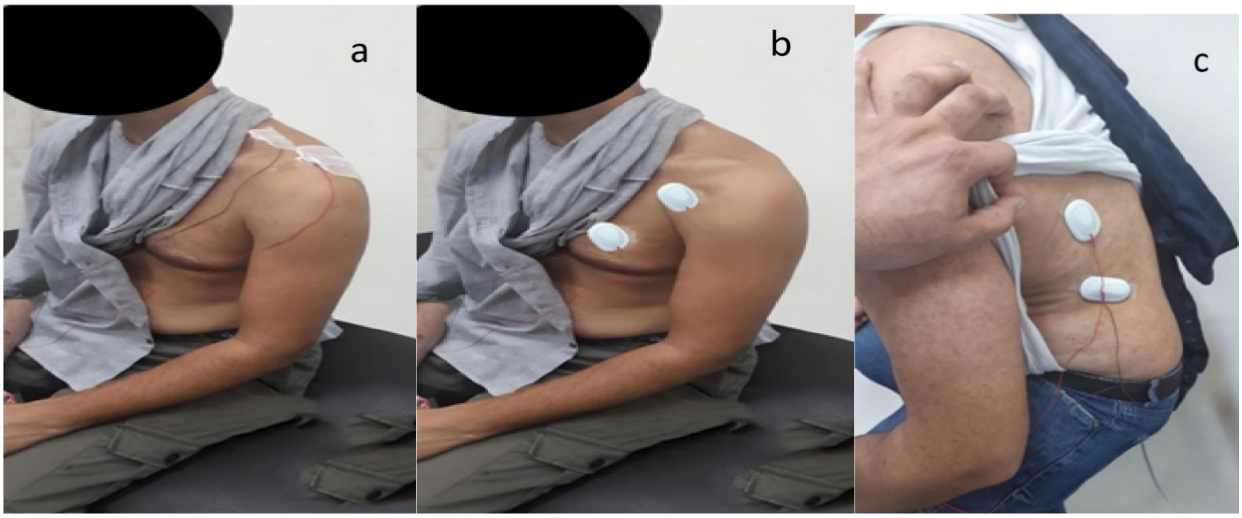

Figure 2. (A) upper fibers of trapezius, (B) pectoralis major and(C) latissimus dorsi electrode locations for recording EMG signals.

DISCUSSION

The results demonstrate limited functional intermuscular correlations during MVICs. Only FCR contraction produced a moderate association between trapezius and pectoralis major, suggesting selective functional connectivity between ventral and lateral chains. Most other correlations were weak, indicating that anatomical continuity may not necessarily imply strong functional synchronization.

According to the literature on upper limb kinetic chain, up to the best of author knowledge, few studies had examined intermuscular EMG correlations across upper limb myofascial chains during isolated rest MVIC tasks.

The results of this study showed that a change in muscle activity of upper fibers of trapezius showed more change in EMG than other muscles when doing MVIC of ECRB as there are in one chain this suggests functional connectivity along lateral chain pathways and this result concurs with previous Experimental and histological researches showing that the fascia of the trapezius muscle fuses directly with the middle deltoid. From here, continuity with the lateral intermuscular septum of the arm provides the morphological connection to the lower arm, namely the brachioradialis and the ECRB [15]. The correlations were weak between muscles were be tested as there isn`t any myofascial connection between them.

There was a moderate correlation between pectoralis major and upper fibers of trapezius During FCR MVIC; Upper fibers of trapezius and pectoralis major showed more change in EMG than other muscles contraction as brachioradialis lie in both ventral and lateral chain that transmit tension to upper fibers of trapezius and pectoralis major so there was a moderate correlation between pectoralis major and upper fibers of trapezius. During FCR MVICs there were weak correlations between latissimus dorsi and trapezius, latissimus dorsi and pectoralis major. This result concurs with previous research showing that the existence of an anatomical continuity between all the muscles of the flexor region of the upper limb and the myofascial connections create an anatomical continuity between different muscles involved in the same directional [15,16].

This study showed that a change in muscle activity of latissimus dorsi in EMG than other muscles During ECU MVIC as both latissimus dorsi and ECU are in dorsal chain this result concurs with previous Experimental and histological researches showing that the fascia of the latissimus dorsi and the infraspinatus and teres minor muscles fuse with the triceps brachii. At the elbow, the latter merges with the small anconeus muscle, which then connects to the ECU of the lower arm [15]. All correlations were weak between muscles measured During ECU MVIC as there isn`t any myofascial connection between them.

Some clinical applications could be drawn from our findings; Muscular pain or dysfunction has to affects muscle activation patterns [17], impairing normal motion and function in kinetic chains. This may help in identifying the cause of impairment and solving it.

Limitations

The study included only young healthy individuals. Surface EMG may be affected by crosstalk. The seated testing position may limit generalizability.

CONCLUSION

Selective functional correlations were observed between specific upper-limb muscles during MVIC. The results provide partial support for kinetic chain interdependence but suggest limited global functional coupling.

ETHICS APPROVAL

Ethical approval was obtained from the Faculty of Physical Therapy Research Committee, Cairo University (Approval No: P.T.REC/012/005146). Written informed consent was obtained from all participants.

INFORMED CONSENT

All participants obtained informed consent before involvement in the study. The head of the study `s setting was granted permission to collect the data which stored it in a lock to preserve the participants` privacy.

DISCLOSURE STATEMENT

No author has any financial interest or received any financial benefit from this research.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

No external funding was received for this study.

REFERENCE

1. Myers, T. W. Anatomy Trains: Myofascial Meridians for Manual Therapists and Movement Professionals (4th Ed.). Edinburgh: Churchill Livingstone. 2020 (pp. 1-15).
2. Schleip, R., Findley, T. W., Chaitow, L., & Huijing, P. A. (Eds.). Fascia: The Tensional Network of the Human Body. The science and clinical applications in manual and movement therapy. Edinburgh: Churchill Livingstone. 2012 (pp. 1-12).
3. Adstrum, S., Nicholson, H., & Dilley, A. Defining the fascial system. Journal of Bodywork and Movement Therapies, 2023 34, 64-72.
4. Myers, T. W. Anatomy Trains (4th ed.). Edinburgh: Churchill Livingstone. 2020 (Chapters 7 & 8, specifically pp. 147-178).

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5. Wilke J, et. al., Appraising the methodological quality of cadaveric studies: validation of the QUACS scale. J Anat 2015, 226, 440–446.
6. Martin H.S, et.al. Surface electromyographic recordings after passive and active motion along the posterior myofascial kinematic chain in healthy male subjects Journal of Bodywork & Movement Therapies 2013
7. Huijing, P. A. Epimuscular myofascial force transmission: a historical perspective and implications for new research. Journal of Biomechanics, 2009 42(1), 9–21.
8. Krause, F., Wilke, J., Vogt, L., & Banzer, W. Intermuscular force transmission along myofascial chains: a systematic review. Journal of Anatomy, 2016 228(6), 910–918.
9. Wilke, J., Krause, F., Vogt, L., & Banzer, W. What is evidence-based about myofascial chains: a systematic review. Archives of Physical Medicine and Rehabilitation, 2016, 97(3), 454-461.
10. Sueki, D. G., Cleland, J. A., & Wainner, R. S. A regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. Journal of Manual & Manipulative Therapy, 2013, 21(2), 90–102.
11. Strutton, P. H., & Wright, A. The role of the thorax in shoulder pain. In Physical Therapy of the Shoulder 2018, (pp. 119-135). Churchill Livingstone.
12. Wilke, J., et al. The effect of myofascial release on range of motion: a systematic review and meta-analysis. Journal of Sport Rehabilitation, 2020, 29(4), 529-536.
13. Casato, G., et al. Effects of myofascial release techniques on motor neuron excitability: a systematic review. Journal of Clinical Medicine, 2021,10(16), 3553.
14. Ramani PK, Lui F, Arya K, Nerve conduction studies and electromyography. [Updated 2025 Feb 10]. In: Stat Pearls [Internet]. Treasure Island (FL): Stat Pearls Publishing ;2026 Jan-available from: http://www.ncbi.nlm.nih.gov/books/nbk611987/
15. Wilke J. And Krause f. Myofascial Chains of the Upper Limb: A Systematic Review of Anatomical Studies Wiley Online Library 2019
16. Stecco A, Macchi V, Stecco C, Porzionato A, Ann Day J, Delmas V, De Caro R. Anatomical study of myofascial continuity in the anterior region of the upper limb. J Bodyw Mov Ther. 2009 Jan;13(1):53-62. doi: 10.1016/j.jbmt.2007.04.009. Epub Jun 28. PMID: 19118793.
17. Wilke, J., & Schleip, R. The myofascial system: a review of its anatomy, physiology, and treatment techniques. Current Pain and Headache Reports, 2021, 25(6), 39.