Influence of isometric hip extension on contralateral lower trapezius electromyographic activity during scapular retraction

Influencia de la extensión isométrica de cadera sobre la actividad electromiográfica del trapecio inferior contralateral durante la retracción escapular

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Received: 17-03-26
Accepted: 08-05-26

How to cite in APA

Soto-Martínez, A., Maureira Pareja, H., Guede-Rojas, F., Carvajal-Parodi, C., Lagos-Hausheer, L., & Jerez-Mayorga, D. (2026). Influence of isometric hip extension on contralateral lower trapezius electromyographic activity during scapular retraction. *Retos, 81*, 77-88. https://doi.org/10.47197/retos.v81.119051

Abstract

Introduction: Traditional models describe force transmission as a myotendinous pathway from muscle to bone; however, growing evidence supports myofascial force transmission to adjacent structures, including via the thoracolumbar fascia (TLF). The influence of lower limb activation remains unclear.
Objective: To investigate the influence of isometric hip extensor effort on bilateral lower trapezius (LT) electromyographic (EMG) activity during scapular retraction and neutral shoulder position.
Methods: Fifteen healthy male participants were evaluated in four randomized conditions: NPWA (neutral position without lower limb action), NPEA (neutral position with lower limb action), RPWA (scapular retraction without lower limb action), and RPEA (scapular retraction with lower limb action). Surface EMG of left and right LT was recorded and normalized to maximum voluntary isometric contraction, and peak root mean square values were analyzed. Repeated measures ANOVA and post-hoc Bonferroni tests were applied.
Results: Left LT activity was significantly lower in RPEA compared to RPWA (Δ=-12.97%, p=0.034, d=0.73). Right LT activity also decreased in RPEA (Δ=-9.40%), though not significantly (p=0.078). No differences were found between NPWA and NPEA. Both retraction conditions (RPWA, RPEA) showed significantly greater LT activation than neutral conditions (p<0.01).
Conclusion: Isometric lower limb effort reduced contralateral LT activation during scapular retraction, suggesting a potential contralateral myofascial modulation via the thoracolumbar fascia.

Keywords

Force; electromyography; lower trapezius; lower limb; myofascial force transmission.

Resumen

Introducción: Los modelos tradicionales describen la transmisión de fuerza como una vía miotendinosa desde el músculo hacia el hueso; sin embargo, existe evidencia creciente que respalda la transmisión miofascial de fuerza hacia estructuras adyacentes, incluyendo a través de la fascia toracolumbar (FTL). La influencia de la activación del miembro inferior aún no está claramente establecida.
Objetivo: Investigar la influencia del esfuerzo isométrico de los extensores de cadera sobre la actividad electromiográfica (EMG) bilateral del trapecio inferior (TI) durante la retracción escapular y en posición neutra del hombro.
Métodos: Quince participantes masculinos sanos fueron evaluados en cuatro condiciones aleatorizadas: NPWA (posición neutra sin acción del miembro inferior), NPEA (posición neutra con acción del miembro inferior), RPWA (retracción escapular sin acción del miembro inferior) y RPEA (retracción escapular con acción del miembro inferior). Se registró la EMG de superficie del TI izquierdo y derecho, normalizada respecto a la contracción isométrica voluntaria máxima, y se analizaron los valores máximos de la raíz cuadrática media (RMS). Se aplicó un ANOVA de medidas repetidas y pruebas post-hoc de Bonferroni.
Resultados: La actividad del TI izquierdo fue significativamente menor en RPEA en comparación con RPWA (Δ=-12.97%, p=0.034, d=0.73). La actividad del TI derecho también disminuyó en RPEA (Δ=-9.40%), aunque sin alcanzar significación estadística (p=0.078). No se encontraron diferencias entre NPWA y NPEA. Ambas condiciones de retracción (RPWA, RPEA) mostraron una activación del TI significativamente mayor que las condiciones neutras (p<0.01).
Conclusión: El esfuerzo isométrico del miembro inferior redujo la activación contralateral del TI durante la retracción escapular, lo que sugiere una posible modulación miofascial contralateral a través de la fascia toracolumbar.

Palabras clave

Fuerza; electromiografía; trapecio inferior; miembro inferior; transmisión miofascial de fuerza.

Introduction

Muscular force has traditionally been described as being generated within muscle fibers and transmitted in series to the skeleton through the tendon, a process known as myotendinous force transmission (Trotter et al., 1985). However, contemporary biomechanical perspectives suggest that muscles do not act as mechanically isolated units, but rather as actuators embedded within a connective tissue network capable of redistributing forces to adjacent and distant structures (Herbert et al., 2008; Huijing, 2009; Maas & Sandercock, 2008). This phenomenon, broadly referred to as myofascial force transmission (MFT), involves the transmission of tension through intramuscular, intermuscular, and extramuscular connective tissues, including the endomysium, perimysium, epimysium, fascia, neurovascular tracts, and adjacent non-muscular structures (Bernabei et al., 2016; Huijing, 2009; Purslow, 2010; Yucesoy, 2010). From a clinical perspective, this concept suggests that local muscle activation may have distant mechanical or neuromuscular effects, with potential implications for rehabilitation and exercise prescription.

Evidence supporting MFT has been reported in animal models (Maas et al., 2001, 2005), cadaveric tissues (Barker et al., 2004; Vleeming et al., 1995), and in vivo human studies (Ajimsha et al., 2022). Ultrasound investigations have demonstrated force transmission between the gastrocnemius and hamstrings, modulated by knee angle (Mohr et al., 2023). Earlier findings align with these observations, with heterogeneous deformations reported in synergistic and antagonistic gastrocnemius muscles when knee and hip joint angles are altered (Yaman et al., 2013), and applying global or local tension to the gastrocnemius induces mechanical changes in the soleus (Huijing et al., 2011). Furthermore, myofascial connectivity between the pelvis and the deep fascia of the medial gastrocnemius has been demonstrated, as pelvic movement displaces distal fascial structures (Cruz-Montecinos et al., 2015). Collectively, these results suggest that MFT is mediated by complex interactions among synergistic muscles.

A potential pathway for long-distance ipsilateral or contralateral MFT from the lower to the upper limb may involve the extensive connections of the superficial layer of the thoracolumbar fascia (TLF), which integrates the gluteus maximus (GM), latissimus dorsi (LD), and lower trapezius (LT) muscles (Willard et al., 2012). Cadaveric studies have shown that isolated tension applied between these muscles produces significant displacement of the TLF, suggesting that they function as a mechanically coupled unit (Barker et al., 2004; Vleeming et al., 1995). The functional role of the TLF has been supported by evidence demonstrating cranio-caudal MFT between the contralateral GM and the LD in an in vivo human model (Carvalhais et al., 2013). Although this cranio-caudal line of action between the GM and LD via TLF has been previously described, it remains of interest to investigate whether GM activation during hip extensor effort may influence, in a cephalad direction, the activation of scapular muscles such as the LT. In this regard, it has been shown that the posterior layer of the TLF can transmit forces from isometric GM contractions to the LD and LT, significantly affecting resting muscle activity (Marpalli et al., 2022).

The clinical relevance of MFT in rehabilitation lies in its potential application to therapeutic exercise aimed at targeting specific muscle groups in various musculoskeletal disorders (De Mey et al., 2013). In particular, the LT plays a key role in motor control and scapular stabilization, and its activation has been shown to be reduced in conditions such as scapular dyskinesis and subacromial impingement syndrome (Diederichsen et al., 2009; Pirauá et al., 2014). Furthermore, it has been suggested that MFT may influence scapular muscle recruitment due to the myofascial connections linking the lower limbs, spine, and shoulder girdle (Maenhout et al., 2010).

During therapeutic exercise, some studies have reported that lower limb muscle recruitment increases the electromyographic (EMG) activity of the LT in overhead athletes (Maenhout et al., 2010; De Mey et al., 2013); however, another similar study found no significant changes (Nakamura et al., 2016). It is important to note that these investigations used different exercise modalities and assessed concentric LT activation without controlling the amount of force produced by the lower limb. A previous study demonstrated force transmission from the LD to the contralateral GM via the TLF under both passive and active tension conditions, without requiring voluntary GM contraction (Carvalhais et al., 2013). Therefore, it remains necessary to clarify whether a controlled isometric hip extensor effort can modulate ipsilateral or contralateral LT activity during scapular retraction or neutral shoulder positions. This lack of evidence limits the understanding of potential myofascial or neuromuscular interactions between the lower limb extensor chain and scapular stabilizers.

Based on this rationale, the primary objective of this study was to determine the influence of controlled isometric hip extensor effort on ipsilateral and contralateral LT EMG activity during both scapular retraction and neutral positions in healthy subjects. A secondary aim was to examine the influence of scapular retraction on bilateral LT activity under two conditions of hip extensor effort. We hypothesized that isometric hip extensor effort would significantly reduce contralateral LT activity during scapular retraction, possibly due to myofascial tension transmission through the TLF.

Method

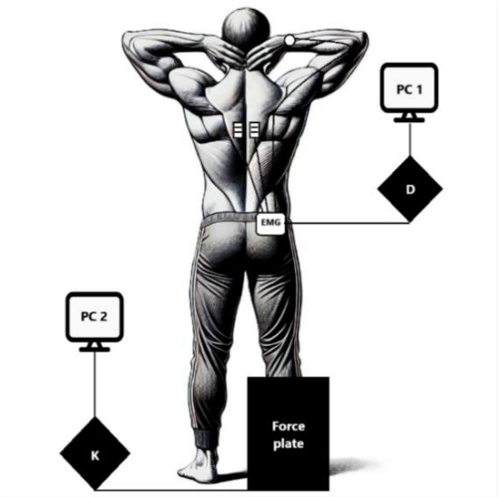
Design and participants

An experimental study with a repeated measures, single-group design was conducted. Participants were recruited by convenience sampling from the Faculty of Health Sciences at the Universidad Católica del Maule, Talca, Chile. Inclusion criteria were: i) healthy males aged 18 to 25 years; ii) normal body mass index (BMI: 18.5–24.9 kg/m^2); and iii) ability to correctly perform all protocol procedures. Only male participants were included to reduce potential variability associated with sex-related physiological differences and hormonal factors that may influence neuromuscular and electromyographic responses. Exclusion criteria included: i) moderate to severe musculoskeletal pain within the past 6 months, assessed using the visual analog scale (VAS); ii) history of musculoskeletal injuries during the same period; and iii) presence of scapular dyskinesis, evaluated during bilateral active shoulder elevation (Kibler et al., 2002) in the maximum voluntary isometric contraction (MVIC) test for the LT. All criteria were verified during an initial interview using a structured checklist. All participants provided written informed consent. The study was approved by the Bioethics Committee of the Universidad Católica del Maule (approval number 51/2018).

Procedure

The procedures were divided into three stages: i) familiarization with the testing protocols, ii) measurement of bilateral EMG activity of the LT and hip extensor force of the dominant leg during a MVIC, iii) measurement of normalized bilateral LT EMG activity under four test conditions. For EMG acquisition, the skin was shaved and cleaned with isopropyl alcohol at the electrode sites to reduce impedance. Surface electrodes were placed obliquely upward and laterally at two-thirds along the imaginary line from the scapular spine to the seventh thoracic vertebra (De Mey et al., 2013). The reference electrode was positioned on the distal ulna at the right wrist. EMG signals were recorded at a sampling frequency of 1000 Hz and a gain of 1000, following the protocol of a previous study (Arlotta et al., 2011). Participants stood upright (feet shoulder-width apart), placing the dominant lower limb foot just in front of a vertically mounted force platform. For the required test conditions, upon verbal instruction, participants applied an isometric hip extension effort using the posterior aspect of the heel, with the knee fully extended. The non-dominant leg was placed on a platform to equalize foot height. The force platform sampled at 100 Hz. Figure 1 illustrates the experimental setup.

Figure 1. Biomechanical experimental setup diagram.



Note. Posterior view of the experimental setup used to record lower trapezius EMG activity and hip extensor effort. D: Delsys electromyography device; EMG: electromyography electrodes; K: Kistler force platform; PC: computer.

EMG signals were normalized as a percentage of MVIC, obtained using the prone row procedure (Arlotta et al., 2011). Briefly, participants lay prone with the shoulder abducted to approximately 90° and externally rotated, pulling upward against manual resistance to elicit maximal LT activation. To determine MVIC, three 8-second trials were performed with standardized verbal encouragement and 30-second rest intervals between repetitions. For analysis, the trial with the highest root mean square (RMS) value was selected. The MVIC test was performed with both hands behind the head and scapular retraction, with the elbows abducted to approximately 90° and the glenohumeral joints positioned at approximately 120° of abduction/flexion, as this position has been shown to elicit higher LT activation when the arm is positioned above 90° of abduction and flexion (Bressel et al., 2001; Reinold et al., 2009).

The four test conditions for EMG recording (Figure 2) were randomized using a sequence generator in Microsoft Excel. The test conditions were:

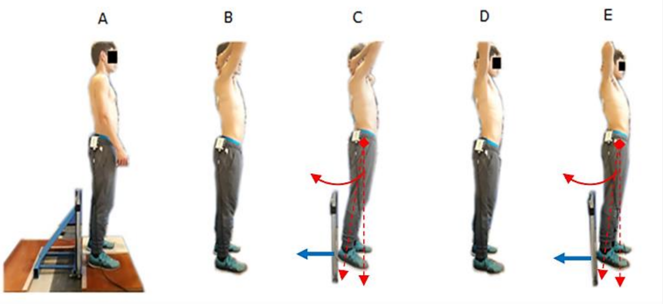
i. Neutral position without lower limb action (NPWA): hands placed behind the head, with the elbows abducted to approximately 90° and the glenohumeral joints positioned at approximately 120° of abduction/flexion, without scapular retraction, maintained for five seconds.

ii. Neutral position with lower limb action (NPEA): from the neutral scapular position, an isometric hip extension effort at 30% of MVIC was performed for five seconds.

iii. Scapular retraction position without lower limb action (RPWA): from the neutral scapular position, voluntary scapular retraction was performed for five seconds.

iv. Scapular retraction position with lower limb action (RPEA): from the neutral scapular position, scapular retraction and an isometric hip extension effort at 30% of MVIC were simultaneously performed and maintained for five seconds.

Figure 2. Randomized measurement protocol.



Note. A: initial standing position; B: neutral position without lower limb action (NPWA); C: neutral position with lower limb action (NPEA); D: scapular retraction position without lower limb action (RPWA); E: scapular retraction position with lower limb action (RPEA). The arrows indicate the direction of the hip extension effort applied against the force platform.

Each condition was performed in two consecutive repetitions, with 30 seconds of rest between repetitions and two minutes between conditions. For analysis, the highest EMG signal value (RMS) from both repetitions was selected for each condition. An intensity of 30% of MVIC was used to standardize the hip extensor effort, as this submaximal load minimizes postural destabilization while ensuring measurable muscle activation. Force output was continuously monitored on the force platform to maintain the required intensity throughout the task.

All participants were instructed to maintain an upright trunk posture without compensatory leaning. Additionally, all conditions were monitored with verbal and visual feedback displayed on a screen to ensure proper execution and accurate force control.

Instrumentation

To control the hip extensor muscular effort, a Kistler force platform model 9287B (Kistler Instruments AG, Winterthur, Switzerland) was used, and data were analyzed using BioWare software (version 3.0, Kistler Instruments). For electrophysiological measurements, a Delsys Bagnoli-8 electromyograph (Delsys Inc., Natick, Massachusetts) was employed. Surface electrodes were double differential, 99% silver (DE-3.1; Delsys, Inc.), with three parallel bars spaced 10 mm apart, impedance greater than 10^{15} Ω//0.2 pF, a common mode rejection ratio of 92 dB, and a gain voltage of 10. EMG data were processed using EMGWorks™ Acquisition software, and an analog-to-digital conversion card (National Instruments, 16-bit, PCI-6220/6224) was used.

Data reduction

EMG processing was performed using the central segments of the signal corresponding to the time interval between seconds 3 and 7 for the MVIC recording, and between seconds 2 and 4 for the evaluative conditions. The signals were centered and filtered using a 20 Hz high-pass and a 450 Hz low-pass filter to smooth the signal. Additionally, a stop-band filter was applied to eliminate 50 Hz noise, verified using the fast Fourier transform. The RMS of the signals was then calculated to normalize muscle activation in the evaluative conditions relative to the MVIC, using the formula: $\% = (\text{RMS condition} / \text{RMS MVIC}) \times 100$. All analyses were performed in MATLAB® (MathWorks, Natick, MA, USA).

To control hip extensor effort, 30% of the force on the Z-axis (anteroposterior) obtained during the MVIC was used, in order to avoid postural destabilization. Additionally, an acceptance criterion was set such that the force on the X (mediolateral) and Y (vertical) axes did not exceed 15% of the Z-axis force. Muscular effort was ultimately expressed as torque in Newton-meters (Nm), calculated using the formula: $\text{Torque} = \text{Force (N)} \times \text{moment arm (m)}$. The moment arm was measured as the distance from the greater trochanter to the heel using a standard measuring tape.

Data analysis

The sample size (n = 15) was calculated a priori using a one-factor repeated measures ANOVA (4 levels) with a single primary outcome variable (EMG activity), assuming a statistical power of 80%, a moderate effect size, and a significance level of 5%, using GPower software (version 3.1.7).

Normality was assessed using the Shapiro–Wilk test, and sphericity was tested using Mauchly's test. To assess differences in normalized EMG activity between conditions for each LT, a two-way repeated measures ANOVA was conducted with the factors “muscle” (left and right LT; 2 levels) and “condition” (NPWA, NPEA, RPWA, RPEA; 4 levels), followed by Bonferroni post hoc tests for multiple comparisons.

Effect sizes (Cohen's d) were also calculated and categorized as small (≤ 0.5), moderate (0.5–0.8), or large (> 0.8). Statistical analyses were performed using SPSS software (version 23), with a significance level set at 5%. Effect sizes were calculated using GPower (version 3.1.7). Graphs were created with GraphPad Prism (version 6, GraphPad Software, Inc.).

Results

Seventeen participants were initially recruited; however, two were excluded due to not meeting the inclusion criteria (BMI > 30 kg/m^2). The final sample consisted of 15 healthy male participants, all with right lower limb dominance. Demographic characteristics, normalized EMG activity levels, and hip extensor effort values are presented in Table 1. All participants completed the protocols without any adverse events. The two-way repeated-measures ANOVA revealed no significant main effect of muscle (F(1, 14) = 0.15, p = 0.70), indicating no overall difference between the left and right LT. A significant main effect of condition was observed (F(1.94, 27.21) = 59.60, p < 0.01). The muscle × condition interaction was not statistically significant [F(3, 42) = 2.41, p = 0.08]. Likewise, there were no significant differences in hip extensor effort between the NPEA and RPEA conditions (p > 0.05).

Table 1. Demographic characteristics, normalized electromyographic activity, and dominant lower limb force/torque.

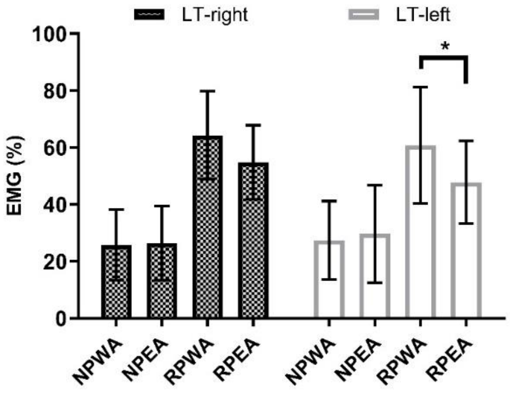
	Outcomes	Total (n=15), Mean ± SD.
Demographic characteristics.	Age (years)	20.27± 2.31
	Height (m)	1.71 ± 0.06
	Weight (kg)	67.71 ± 7.69
	BMI (kg/m^2)	22.99 ± 1.62
	LLL (m)	0.84 ± 0.06
EMG, LT-Left[a].	NPWA	27.4 ± 13.7
	NPEA	29.6 ± 17.1
	RPWA	60.7 ± 20.4
	RPEA	47.8 ± 14.6
EMG, LT-Right[a].	NPWA	25.8 ± 12.4
	NPEA	26.4 ± 13.0
	RPWA	64.2 ± 15.5
	RPEA	54.8 ± 13.0
lower limb force/torque.	MVF-EEII (N)	94.99 ± 44.63
	AF-NPEA (N)	31.54 ± 13.44
	AF-RPEA (N)	30.59 ± 11.87
	T-NPEA (Nm)	27.7 ± 12.65
	T-RPEA (Nm)	26.81 ± 11.24

Values are presented as mean ± SD; MVF: Maximum voluntary force; AF: Average force; BMI: Body mass index; LLL: Lower limb length; %: Percentage; Kg: Kilogram; n: Sample size; m: Meter; T: Torque; [a]: Normalized according to the percentage of MVIC; Experimental conditions are defined in the Methods section.

Differences in LT EMG activity were observed based on the combination of scapular retraction and hip extensor effort. In the left LT, the RPEA condition showed a significant reduction compared to RPWA, with a mean difference (Δ) of -12.97% (95% CI: -21.49 to -0.77, p < 0.05) and a moderate effect size (d=0.73). In the right LT, the difference between RPEA and RPWA was -9.40%, which did not reach statistical significance (95% CI: -19.54 to 0.73, p > 0.05), although the effect size was moderate (d=0.66). No significant differences were found between NPWA and NPEA in the left LT (Δ=-2.27%, 95% CI: -11.85 to 7.31, p > 0.05, d=0.14, small effect) or in the right LT (Δ =-0.66%, 95% CI: -10.41 to 9.08, p > 0.05, d=0.04, small effect).

Additionally, the conditions involving scapular retraction (RPWA and RPEA) showed significantly higher EMG activity compared to the non-retraction conditions (NPWA and NPEA) in both LTs (p < 0.01). In the left LT, the difference between RPWA and NPWA was 33.36% (95% CI: 19.69 to 47.03; p < 0.01), with a large effect size (d=1.92), and between RPEA and NPEA was 18.12% (95% CI: 5.17 to 31.07; p < 0.01, d=1.14, large effect). In the right LT, the difference between RPWA and NPWA was 38.43% (95% CI: 25.69 to 51.16; p < 0.01), with a large effect size (d=2.74), and between RPEA and NPEA was 28.37% (95% CI: 19.56 to 37.17; p < 0.01, d=2.19, large effect). These results are summarized in Figure 3.

Figure 3. Differences in electromyographic activity across measurement conditions.



Note. Values are presented as mean ± standard deviation. EMG values are expressed as a percentage of maximum voluntary isometric contraction. LT: lower trapezius; NPWA: neutral position without lower limb action; NPEA: neutral position with lower limb action; RPWA: scapular retraction position without lower limb action; RPEA: scapular retraction position with lower limb action; %: percentage; * Significant difference at the 0.05 level.

Discussion

The primary aim of this study was to determine the influence of controlled hip extensor effort on bilateral LT EMG activity in healthy individuals. The findings were as follows: (i) under scapular retraction conditions, only the left LT showed reduced EMG activity when lower limb extension was added (RPEA vs RPWA), whereas the right LT did not show significant differences between these same conditions; and (ii) secondarily, both LTs exhibited higher EMG activity during the scapular retraction conditions (RPWA and RPEA) compared to the non-retraction conditions (NPWA and NPEA).

Connective tissue plays a key role in MFT (Huijing, 2009), with the TLF serving as a potential pathway for force transmission between lower and upper limb actions. Anatomical studies have shown that the TLF provides a cross-linked connection between the GM and the LT, suggesting the possibility of epimuscular MFT (Vleeming et al., 1995; Willard et al., 2012). Few studies have investigated force transmission between the GM and LT, and most have focused solely on its potential therapeutic application without measuring lower limb force or its effect on LT during isometric activation (Maenhout et al., 2010; De Mey et al., 2013; Nakamura et al., 2016). Moreover, findings remain inconsistent: some studies have reported increased concentric LT contraction following contralateral lower limb activation (Maenhout et al., 2010; De Mey et al., 2013), while another study found no evidence of MFT effects (Nakamura et al., 2016).

Regarding the EMG recording method, the central segment of the EMG signal from the LT was analyzed for each participant during the hip extension effort performed at 30% of maximal force. This approach was used to standardize the intensity of effort and allow consistent comparisons across conditions. This target force level was successfully achieved by the participants, as confirmed by the recorded data.

When comparing EMG activity between the scapular retraction and neutral positions, the results indicate that scapular retraction elicits significantly greater LT activation on both the right and left sides. This finding reinforces the notion that isometric scapular retraction is a movement that facilitates selective and high activation of the LT (Arlotta et al., 2011; Moseley et al., 1992; Oyama et al., 2010). Notably, the mean activation values exceeded 50% of MVIC, which qualifies as high muscular activation (>50%) according to previous criteria (McCann et al., 1993). This elevated activation may be attributed to the hands-behind-head position, which places the glenohumeral joint at approximately 120° of abduction and flexion (Bressel et al., 2001; Reinold et al., 2009). In agreement, previous studies have shown a progressive increase in LT activation above 90° of shoulder elevation (Bressel et al., 2001; Reinold et al., 2009).

When analyzing the differences in LT EMG activity between conditions with and without lower limb action, it was observed that only the left LT, during scapular retraction, showed a significant reduction in muscle activation when hip extension effort was incorporated. This difference represented a decrease of approximately 13% compared to RPWA, with a moderate effect size. Myofascial connections may offer a plausible explanation for these findings; however, the exact contralateral transmission pathway through the TLF should be interpreted with caution. The GM and LD are anatomically connected through the posterior layer of the TLF, suggesting a potential pathway for load transfer between the pelvis, trunk, and shoulder girdle (Vleeming et al., 1995). In addition, unilateral isometric GM contraction has been associated with EMG activity changes in bilateral LD and LT muscles (Marpalli et al., 2022), suggesting that force transmission through the posterior layer of the TLF may occur toward both the same and opposite sides. However, some authors have questioned the influence of the TLF during physiological in vivo movement, arguing that previous experimental models did not evaluate force transmission within normal physiological ranges of motion (Herbert et al., 2008; Maas & Sandercock, 2008). Therefore, because the present study did not directly measure GM activation, fascial displacement, or tissue strain, these findings should be interpreted as indirect evidence of a possible myofascial or neuromuscular modulation rather than as direct confirmation of contralateral force transmission through the TLF.

Among the main reasons that, in the authors' opinion, may explain the reduction in EMG activity of the LT contralateral to the extended leg, it is proposed that during hip extension, the myofascial tissues may have altered the length-tension relationship of the LT under isometric conditions. In this regard, experimental evidence from animal models has shown that changes in the position of one muscle relative to another connected via connective tissue can result in intermuscular myofascial force transmission and a reduction in proximal isometric force (Maas et al., 2005). Complementarily, anatomical and biomechanical evidence concerning the TLF indicates that tension applied through GM-related fascial attachments may displace the TLF distally by 4 to 7 cm (Vleeming et al., 1995; Willard et al., 2012), which may position the LT at a longer length, thereby reducing its force-generating capacity. In addition to this mechanical explanation, a neurophysiological mechanism may also be considered. Increased tension within fascial tissues during hip extension could stimulate fascial mechanoreceptors and modify afferent feedback, potentially contributing to reflex modulation or inhibition of LT motor output (Beardsley & Škarabot, 2015). Similar mechanosensory explanations have been proposed in relation to changes in fascial tension and tactile stimulation of mechanoreceptors influencing muscle response (Gajardo Contreras et al., 2021). However, because fascial mechanoreceptor activity was not directly assessed, this explanation remains hypothetical. This mechanical and neurophysiological rationale may have a neuromuscular correlate, as recent studies have demonstrated that variations in muscle fascicle length are directly associated with changes in EMG activity, even during isometric contractions (Jiroumaru et al., 2014; Martinez-Valdes et al., 2022).

Previous studies have reported findings contrary to those of the present study, indicating an increase in LT EMG activity following activation of the contralateral lower limb (Maenhout et al., 2010; De Mey et al., 2013). An 8.82% increase in LT activation has been observed during a knee push-up exercise performed with the contralateral leg (Maenhout et al., 2010). Similarly, a 3.93% increase in LT activation has been reported during a single-leg squat on the contralateral side (De Mey et al., 2013). Although these changes were of small magnitude, they may still be functionally relevant given the stabilizing role of the LT in the scapulothoracic joint. One possible explanation for the discrepancies with our findings lies in methodological differences. In a previous study, a scapular protraction movement was performed, which is the opposite of the scapular retraction used in our study (Maenhout et al., 2010). In contrast, dynamic scapular retraction from 90° to 0° of glenohumeral flexion has been evaluated previously, whereas our protocol maintained the arms in a static position of approximately 120° of flexion/abduction (De Mey et al., 2013). This variation in glenohumeral angle alters the length and moment arm of the LT. Moreover, dynamic kinetic-chain exercises may impose greater scapular stabilization demands and coordinated muscle activation to control movement, consistent with recent evidence showing that overhead squat exercises with elastic resistance modulate shoulder muscle recruitment and enhance activation of scapular stabilizers such as the LT and serratus anterior (Salles & Pascoal, 2026). In contrast, the present protocol involved static scapular retraction combined with isometric hip extension; therefore, passive stiffness and myofascial tension may have contributed more prominently than dynamic stabilizing demands. Additionally, in our study, the hip was maintained in an isometric extension effort, which may affect myofascial transmission and LT electromyographic response differently.

Regarding the stabilizing role of the LT, it has been suggested that its activation may increase in response to scapular destabilization caused by contralateral LD activation. This hypothesis is supported by evidence indicating that the LD contributes to scapular stability during dynamic exercises in both open and closed kinetic chains and likely serves as a myofascial force transmitter alongside the LT (Kaur et al., 2014). Collectively, these previous findings suggest that during dynamic exercises and active upper limb movement, increased LT EMG activity may be explained by its stabilizing function. In contrast, in the present study—where both scapular retraction and hip extension were performed isometrically—changes in LT EMG activity are more likely attributable to structural mechanisms, such as muscle architecture and passive myofascial connections.

Regarding the influence of right lower limb activation on right LT electromyographic activity, our results showed no statistically significant changes. Nevertheless, the moderate magnitude of the observed reduction suggests a possible trend that should be interpreted cautiously and further examined in studies with larger samples. Similarly, ipsilateral leg extension has been reported not to significantly alter LT muscle recruitment, suggesting that this type of activation does not exert a direct effect on the muscle (Maenhout et al., 2010). In our study, a non-significant reduction (9.4%) in right LT activity was observed, which may be attributed to indirect force transmission through the left leg, which remained in support during right hip extension. From a mechanical perspective, to effectively perform right leg extension against resistance, the left lower limb and left hemibody likely acted as stabilizers in a closed kinetic chain, increasing tension to provide the necessary fixed point. These findings do not support a clear diagonal facilitation pattern, as proposed in other cross-activation models, but rather suggest a modulation dependent on postural context and contraction type. Therefore, this response should be considered when prescribing scapular retraction exercises aimed at maximizing or modulating LT activation in patients with scapular dysfunction.

From a clinical perspective, contralateral isometric hip extension should be prescribed with caution during scapular retraction exercises aimed at maximizing LT activation, particularly in patients with scapular dyskinesis or LT weakness. Conversely, this strategy could be explored when the goal is to reduce excessive LT activity or overload. However, these implications should be interpreted cautiously because the study was conducted in healthy young males rather than clinical populations.

This study presents several limitations that should be considered. First, the use of surface EMG during muscle contractions may have been affected by skin displacement and variability in electrode placement. However, this effect was minimized by firmly securing the electrodes to the skin. Second, the EMG assessor was not blinded to the experimental conditions, which may represent a potential source of analysis bias. Third, muscle activation of the middle trapezius and serratus anterior was not recorded, limiting interpretation by precluding analysis of potential co-contractions and force-couples. Fourth, hip extension was performed with the knee extended; therefore, this task may have activated not only the gluteus maximus but also the hamstring muscles. Because gluteus maximus and hamstring EMG activity were not recorded, the specific contribution of each hip extensor muscle cannot be determined. Fifth, although the sample size was comparable to similar studies, it does not allow for broad generalization of the findings. Sixth, the use of young, healthy male participants limits the applicability of the results to women, other age groups, and clinical populations. Seventh, participants' strength training level was not objectively controlled; however, all reported a sedentary lifestyle. Lastly, upper and lower limb joint angle variations were not objectively measured during the protocol, although all participants underwent a familiarization session prior to data collection.

The findings of the present study provide a relevant foundation for future research. First, it would be pertinent to investigate the influence of different lower limb positions on LT activation during scapular retraction, using three-dimensional kinematic analysis for more precise evaluation. Second, future studies should examine the effect of supporting lower limb, under closed kinetic chain conditions, on LT activation at varying effort levels relative to the percentage of MVIC. Third, it would be of interest to assess MFT generated during hip extension using imaging techniques applied to the thoracolumbar fascia. Finally, it is recommended to expand the study population to include women, athletes, and individuals with clinical conditions such as scapular dyskinesis, in order to explore the applicability of these findings across diverse functional and pathological contexts.

Conclusions

This study demonstrated that isometric activation of the right lower limb, when combined with scapular retraction, resulted in a reduction of contralateral LT EMG activity. This finding suggests possible mechanical or neurophysiological interaction through myofascial connections, particularly involving the thoracolumbar fascia. From a clinical perspective, contralateral isometric hip extension should be considered with caution when scapular retraction exercises are prescribed to maximize LT activation. While these results support the hypothesis of cross-modulation of muscle control between limbs, further research incorporating imaging techniques and three-dimensional analysis is needed to confirm the underlying mechanisms and to explore their applicability in rehabilitation programs.

Acknowledgements

We thank all the participants for their commitment to the development of this research. This study was developed within the framework of the Master's Program in Kinesiology at Universidad Católica del Maule as part of the postgraduate training of Adolfo Soto-Martínez.

Financing

This study did not receive any external funding.

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