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Backseat Inclination Affects the Myoelectric Activation During the Inclined Leg Press Exercise in Recreationally Trained Men

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Abstract

Marchetti, PH, Gomes, WA, Da Silva, JJ, Magalhaes, RA, Teixeira, LFM, and Whiting, WC. Backseat inclination affects the myoelectric activation during the inclined leg press exercise in recreationally trained men. *J Strength Cond Res* XX(X): 000–000, 2023—Changes in the angle between the seat and backrest during the inclined leg press (ILP) exercise may influence myoelectric activity. The purpose of this study was to evaluate the myoelectric activity between 2 different angles between the seat and backrest (90° and 125°) during the ILP exercise in recreationally trained men. Fifteen young, resistance-trained men (age: 26.8 ± 5.3 years, height: 173.8 ± 6.6 cm, total body mass: 81.6 ± 7.6 kg) performed 1 set of 10 repetitions at 70% of their body mass during the ILP exercise using 2 different angles between the seat and backrest (ILP90° and ILP125°). Surface electromyography (peak RMS_{90} and iEMG) was used to measure the myoelectric activity of the vastus lateralis (VL), biceps femoris (BF), and gluteus maximus (GM). A paired *t* test was used to measure differences in knee and hip joint displacement, peak RMS_{90}, and iEMG between ILP90 and ILP125. The hip angle presented a greater displacement during the ILP125 when compared with ILP90 ($p < 0.001$), considering a similar knee joint displacement. For the VL, there was observed greater myoelectric activation (peak RMS_{90} and iEMG) during ILP125 when compared with ILP90 ($p < 0.05$). For the BF, there was observed greater myoelectric activation (peak RMS_{90} and iEMG) during ILP90 when compared with ILP125 ($p < 0.05$). However, GM did not present differences between ILP90 and ILP125. In conclusion, the angle between the seat and backrest (ILP90 or ILP125) altered the myoelectric activation of the VL and BF with no difference for the GM.

Key Words: strength, performance, lower limb muscles

Introduction

The inclined leg press (ILP) is considered a multijoint (hip, knee, and ankle) exercise that engages several muscle groups (i.e., quadriceps femoris, hamstrings, triceps surae, gluteus maximus [GM], etc.) simultaneously in a complex manner. ILP is frequently used in sports, strength and conditioning programs (5), and rehabilitation (4). The ILP exercise uses muscles with different morphology (monoarticular and biarticular), force production depending on joint positions (moment arm, length-tension relationship), and whether the muscle acts as a prime mover or stabilizer (2,6,16). For this reason, the manipulation of the ILP and its variations have been analyzed in several studies (1,5,10,11), including the effects of changes in feet position (low and high) (1,5), stance widths (wide and narrow) (5,10,11), and feet angle positions (5,10,11) on myoelectric activity.

Martin-Fuentes et al. (10) analyzed 10 young trained female subjects on myoelectric activity (vastus medialis oblique, vastus lateralis [VL], rectus femoris, and gluteus medius) under different ILP conditions: feet rotation (0° or 45° external rotation), feet stance width (100 or 150% hip width) on the footplate and 2 different movement velocities (maximum intended and 2-sec:2-sec velocities). The authors concluded that the myoelectric activity pattern for the 0°-100%, 45°-100%, and 0°-150% conditions was similar, with no preferential myoelectric activity. The same authors (11) analyzed 28 healthy young college students (15 men and 13 women) and reported similar results with no significant differences in myoelectric activity related to foot position and width stance.

Da Silva et al. (1) verified the effects of mechanical changes (high and low feet position) and loads (40 and 80% of the 1 repetition maximum) on myoelectric activity during the leg press exercise. Fourteen women were evaluated with electromyographic activity for the rectus femoris, VL, biceps femoris (BF), gastrocnemius, and GM. The results presented differences in myoelectric activity with different loads. The low-feet position had higher myoelectric activity in both loads when compared with the high-feet position. At 40% 1RM, the rectus femoris and gastrocnemius were more active than VL, BF, and GM; at 80% 1RM, the rectus femoris and VL were more active than BF, gastrocnemius, and GM. However, the GM showed greater activity during the high-feet position when compared with the low-feet position. Escamilla et al. (5) analyzed 10 experienced male lifters during the ILP exercise by measuring the effect of different feet positions (high and low), stance widths (wide and narrow), and feet angle positions (feet straight and feet turned out 30°) on

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myoelectric activity (rectus femoris, vastus medialis, VL, lateral and medial hamstrings, and gastrocnemius). Their results showed no differences in the myoelectric activity between angle positions of feet. The wide stance generated higher hamstring activation compared with the narrow stance only during the ILP with a high-feet position. The gastrocnemius presented higher activation during the ILP with a low-feet position when compared with the high position in both stance widths.

In addition, the ILP exercise presents an important joint motion restriction because of the physical contact between the thigh and the trunk limiting the full range of motion. This joint restriction might be influenced by the angle between the seat and backrest during the ILP exercise and could affect myoelectric activity. Stien et al. (16) analyzed the myoelectric activity of 5 hip and knee extensors during the unilateral ILP exercise. Fifteen resistance-trained men performed 6-repetition maximum, and the myoelectric activity was measured. High levels of myoelectric activity were reported for the VL (105.5% maximal voluntary isometric contraction, MVIC), vastus medialis (92.9% MVIC), rectus femoris (69.5% MVIC), and GM (88.0% MVIC). The BF showed lower activity (30.6% MVIC). In addition, Machado et al. (9) measured the myoelectric activity during the ILP exercise. Thirteen female college students performed 10 repetitions at 70% of a 10 repetitions maximum (RM) load, and the myoelectric activity (vastus medialis oblique, VL, rectus femoris, and BF) was recorded. The results showed the following level of myoelectric activity: vastus medialis oblique > VL > rectus femoris > BF. Unfortunately, the GM was not measured in this study. Both studies (9,16) did not compare the effects of seat inclination on myoelectric activity.

To the best of the authors' knowledge, no study has analyzed the effects of seat inclination, during the ILP, on myoelectric activity. The rationale for this study is based on the assumption that changes in seat inclination affect hip position (with similar knee joint movement), and consequently, the range of motion of the hip joint that may modify the myoelectric activity. Therefore, the purpose of this study was to evaluate differences in myoelectric activity and hip joint displacement during the ILP with 2 different angles between the seat and backrest (90° and 125°) in recreationally trained men. The main hypotheses are (a) the VL activation is similar between ILP conditions and (b) hamstrings and GM are more active during the ILP125 than during ILP90.

Methods

Experimental Approach to the Problem

This study used a within-participations design to compare 2 different experimental conditions. All procedures were randomized and counterbalanced across subjects and experimental conditions. Subjects attended one session in the laboratory. All subjects performed 1 set of 10 repetitions with 70% of their body mass (BW) at 30 $b\cdot min^{-1}$ in 1 of 2 experimental conditions: (a) ILP90: 90° between seat and backrest or (b) ILP125: 125° between seat and backrest. After one experimental condition, all subjects rested for 30 minutes and then were asked to perform the other experimental condition. Surface electromyography (sEMG; peak RMS_{90}, and iEMG) was used to measure the myoelectric activity of the VL, BF, and GM.

Subjects

The sample size was justified by a priori power analysis based on a pilot study evaluating the myoelectric activity of the vastus lateralis and gluteus maximus in 4 recreationally trained subjects, with a significance level of 5% and a power of 80%. Therefore, 15 young, healthy, recreationally trained men (age: 26.8 ± 5.3 years, height: 173.8 ± 6.6 cm, total body mass: 81.6 ± 7.6 kg, thigh length: 43.1 ± 3.9 cm, and leg length: 41.1 ± 3.2 cm) volunteered to participate. All subjects had previous resistance training experience for at least 2 years (4.5 ± 2.4 years), experience with leg press exercise, and frequency of 3 times a week with a session for lower limbs. Subjects had no previous lower back injuries, surgery on their lower extremities, and no history of injury with residual symptoms (e.g., pain, "giving-away" sensations) in their lower limbs within the last year. The subjects were informed of the risks and benefits of the study before any data collection and then read and signed an institutionally informed consent document approved by the Institutional Review Board at the University of Sorocaba, Brazil (IRB #5.464.978).

Procedures

All procedures were randomized and counterbalanced across subjects and experimental conditions. Subjects attended one session in the laboratory and refrained from performing any lower-body exercise other than activities of daily living for at least 48 hours before testing. The subjects' anthropometric measurements (height, mass, and lower-limb length [thigh and leg]) were measured. The right thigh length was measured from the proximal end of the greater trochanter and the distal lateral femoral condyle, and the lower leg was measured from the top of the patella (kneecap) and the underside of the foot.

For the ILP (Model 45°-RT054, Tonus Fitness, Brazil) exercise, the subjects sat on the machine, positioning the lower back, hips, and buttocks evenly positioned on the bench. The subjects started the movement with the knees fully extended and then performed the descending phase (eccentric action) of the exercise by flexing the knees and hips in a controlled manner until the knees reached 45° (limited by the researcher). The subjects then performed the ascending phase (concentric action) by extending the knees and hips until returning to the initial position. No time was given between concentric and eccentric actions.

Each subject performed a standardized dynamic warm-up of 15 repetitions with no external load on the ILP. Afterward, all subjects performed a familiarization with the ILP exercise using 1 set of 15 repetitions at 30 $b\cdot min^{-1}$. The subjects' feet were positioned at hip width apart in a comfortable position, the feet position was marked by a tape on the ILP platform, and all subjects were asked to wear their personal pair of shoes during the session. The subjects kept their hands at their sides, holding the equipment's handle. A researcher (CSCS certified) ensured that all subjects performed the exercise correctly, ensuring that the back was always supported by the backrest. After the specific warm-up and familiarization, all subjects performed 1 set of 10 repetitions with 70% of their BW at 30 $b\cdot min^{-1}$ (concentric and eccentric cadence) in 1 of 2 experimental conditions, in a randomized and counterbalanced order: (a) ILP90: 90° between seat and backrest or (b) ILP125: 125° between seat and backrest. The use of 10 repetitions at 70% BW at 30 $b\cdot min^{-1}$ was defined in a pilot study (with the same conditions) aiming to avoid concentric muscle failure with repetition in reserve between 2 and 4. After one experimental condition, all subjects rested for 30 minutes and then were asked to perform the other experimental condition. In the same session, all subjects rested for 15 minutes and then repeated all procedures with a different experimental condition (ILP90 or ILP125), Figure 1.

All subjects received similar verbal encouragement during all conditions. All measurements were performed between 10 AM and 4 PM and measured by the same researcher (CSCS certified).

Electrogoniometry. An electrogoniometer was positioned at the center of the knee joint, and the data were used to define the phases of each repetition. Data were acquired and synchronized with the sEMG using the same acquisition system and software (EMG832C, EMG system Brasil, São José dos Campos, Brazil) with a sampling rate of 2000 Hz.

Surface Electromyography. The subjects' body hair was shaved at the site of electrode placement, and the skin was cleaned with alcohol before affixing the sEMG electrodes. Bipolar active disposable dual Ag/AgCl snap electrodes spanning 1 cm in diameter for each circular conductive area with 2-cm center-to-center spacing were used in all trials. Electrodes were placed on the right limb along the axes of the muscle fibers according to the SENIAM/ISEKI protocol (7): GM at 50% of the distance between the sacral vertebrae and the greater trochanter; VL at two-third of the distance between the anterior spina iliac and the superior aspect of the lateral side of the patella; BF at 50% on the line between the ischial tuberosity and the lateral epicondyle of the tibia. The sEMG signals were recorded by an electromyographic acquisition system (EMG832C, EMG system Brasil, São José dos Campos, Brazil) with a sampling rate of 2000 Hz using a commercially designed software program (EMG system Brasil, São José dos Campos, Brazil). EMG activity was amplified (bipolar differential amplifier, input impedance = 2 MΩ, common-mode rejection ratio of >100 dB min (60 Hz), gain x 20, noise >5 μV) and converted from an analog to digital signal (12 bit). A ground electrode was placed on the right clavicle. The sEMG signals collected during all conditions were normalized to a maximum voluntary isometric contraction (MVIC) against a fixed strap resistance. One trial of five-second MVICs was performed for each muscle with a 1-minute rest interval between actions for the dominant leg. The first MVIC was performed to familiarize the subject with the procedure. For GM MVIC, subjects were in the prone position with their knee flexed at 90° and resistance placed on the distal region of the thigh with the pelvis stabilized (concentric hip extension). For VL MVIC, subjects were in a prone position with their knee flexed at 90° and resistance placed on the distal tibia (concentric knee extension). For BF MVIC, subjects were in a prone position with their knee flexed at 90° and resistance placed on the distal tibia (concentric knee flexion). Verbal encouragement was given during all MVICs. The order of MVICs was counterbalanced to avoid any potential neuromuscular fatigue. The sEMG data and electrogiometer were analyzed with a customized Matlab routine (MathWorks Inc., MA). All sEMG data were defined by the electrogoniometer data, characterizing both the concentric and eccentric phase of each repetition. The digitized angle data were low-pass filtered at 5 Hz using a fourth-order zero-lag Butterworth filter. The first repetition was removed from the data to ensure any body adjustment or change in exercise cadence. Then, the following 5 repetitions were used for further analysis. The digitized sEMG data were band-pass filtered at 20–400 Hz using a fourth-order zero-lag Butterworth filter. For each muscle group the root mean squared (RMS) (250 ms moving window, sEMG RMS) was calculated for the MVICs and the sEMG data. The peak MVIC for each muscle (VL, BF, GM) was used to normalize the sEMG RMS data. Then, for each muscle group, the RMS value (per repetition) at 90 degrees of knee flexion was defined (peak RMS_{90}) and used for further analysis. For the iEMG, the sEMG RMS (normalized by MVIC) from all 5 repetitions was integrated and used for further analysis.

Statistical Analyses

The normality and homogeneity of variances within the data were confirmed by the Shapiro-Wilk and Levene's tests, respectively. Mean, standard deviation, delta percentage (Δ%), and 95% confidence interval ($CI_{95\%}$) were calculated. Test-retest reliability was calculated by intraclass correlation coefficient for all dependent variables. A paired *t* test was used to measure differences in knee joint displacement, peak RMS_{90}, and iEMG between ILP90 and ILP125. Cohen's formula for effect size (*d*) was calculated, and the results were based on the following criteria: <0.35 trivial effect; 0.35–0.80 small effect; 0.80–1.50 moderate effect; and >1.5 large effect for recreationally trained subjects (13). An alpha of 5% was used to determine statistical significance.

Results

For the knee joint displacement, the test-retest reliability was 0.95 for ILP90 and 0.93 for ILP125. There was no significant difference between ILP90 and ILP125 [47.0 ± 5.9° and 47.7 ± 6.2°, respectively, $p = 0.258$, and $CI_{95\%} = -0.5$ to 1.8].

For the peak RMS_{90} (Figure 2A), the test-retest reliability was 0.88 for VL, 0.90 for GM, and 0.81 for BF. There was a significant difference between ILP conditions for VL (ILP90 > ILP125: $p = 0.005$, Δ% = 15, $d = 0.61$ [small], and $CI_{95\%}$ = -7.4 to 8.7) and BF (ILP125 > ILP90: $p = 0.033$, Δ% = 33, $d = 0.66$ [small], and $CI_{95\%}$ = 3.5 to 5.7).

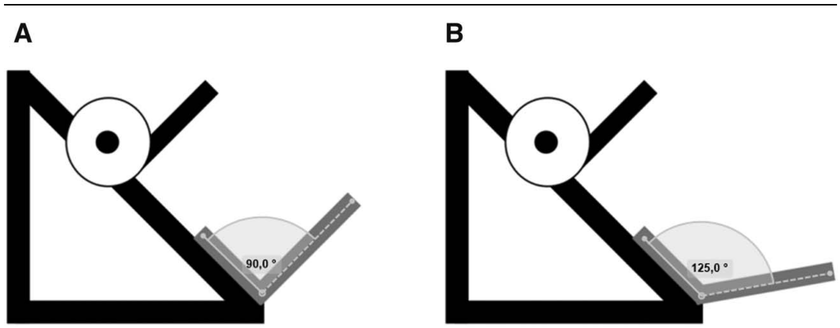

Figure 1. Inclined leg press (ILP) at 45°: (A) 90° between seat and backrest (ILP90) and (B) 125° between seat and backrest (ILP125).

For the iEMG (Figure 2B), the test-retest reliability was 0.90 for VL, 0.92 for GM, and 0.85 for BF. There was a significant difference between ILP conditions for VL (ILP90 > ILP125: $p = 0.001$, $\Delta\% = 16.8$, $d = 0.57$ [small], and $CI_{95\%} = -114.1$ to 39.3) and BF (ILP125 > ILP90: $p = 0.029$, $\Delta\% = 23.7$, $d = 0.47$ [small], and $CI_{95\%} = 17.6$ to 27.9).

Discussion

The purpose of this study was to evaluate differences in myoelectric activity and hip joint displacement during the ILP with 2 different angles between the seat and backrest (ILP90° and ILP125°) in recreationally trained men. The main findings of this investigation were that (a) VL presented greater myoelectric activity (peak RMS_{90} and iEMG) during ILP125, (b) GM did not present different myoelectric activity in both conditions (ILP90 or ILP125), and (c) BF presented greater myoelectric activation (peak RMS_{90} and iEMG) during ILP90.

A multijoint exercise aiming to strengthen the knee and hip extensors is a complex task for the neuromuscular system as the 2 main joints work in concert to achieve an adequate pattern (14). In this study, the knee joint movement was restricted and no significant difference ($p = 0.258$) was observed in both conditions ILP90 (47.0 ± 5.9°) and ILP125 (47.7 ± 6.2°). Therefore, with a similar movement in the knee joint, in both conditions, the hip joint assumes an important role in both conditions studied. In this study, the angle between the seat and the back seat provided a difference in the hip joint position that can affect the relationship between length and tension of the analyzed muscles.

Regarding myoelectric activation (peak RMS_{90} and iEMG), the results showed interesting differences between both ILP conditions (ILP90 and ILP125). Several monoarticular muscles contribute to the ILP movement, including the quadriceps femoris (only the VL was analyzed in this study) and GM (1,5,15,16). It was hypothesized that the VL activation would be similar between ILP conditions. However, the results did not corroborate the main hypothesis because the VL was more active during ILP125 when compared with ILP90 in both analyses (peak RMS_{90}: 15% and iEMG: 16.8%). A possible explanation might be the change in the external force vector during ILP125 when compared with ILP90. In this case (ILP125), the external force vector passes very close to the hip joint and further from the knee joint when compared with the ILP90, and in this way, the ILP125 condition induces the highest myoelectric activation of the VL.

Another important prime mover during the ILP is the GM. GM is a monoarticular muscle responsible for hip extension during the concentric phase of the ILP exercise. In this study, it was hypothesized that the GM would be more active during the ILP125 than during ILP90. However, our results did not corroborate our main hypothesis. In fact, both ILP conditions did not show differences in GM activation. In this study, the GM presented a very low peak RMS_{90} in both conditions (ILP90: 4.2 ± 1.9% MVIC and ILP125: 3.8 ± 2.8% MVIC, $\Delta\% = 9.5$). It is well known that, for monoarticular muscles, the reduction of the moment arm can reduce its activation during exercise, explaining, in part, the low myoelectric activity (12). Conversely, Stien et al. (16) analyzed the GM during the unilateral inclined leg press exercise during 6 RM and observed 88% MVIC of the GM. The difference between studies might be explained by a different strategy to measure the MVIC, load strategy (6 RM vs. 70% BW), or electrode position (considering the GM as a pennate muscle group). A possible explanation for the difference in the myoelectric activity, for both VL and GM, might be related to the change in the direction of the external force vector (related to the external load) between the trunk position and the position of the feet on the platform. In a closed chain exercise like the ILP, changing the position of a segment can affect the performance of the entire exercise, in addition to the load lifted.

During the ILP exercise, several biarticular muscles interact, including the hamstrings, rectus femoris, and gastrocnemius (15). Biarticular muscles present a paradoxical condition because these muscles simultaneously have an agonistic action at one joint and antagonistic action at the other joint (12). Lombard (8) suggested that biarticular muscles of the lower extremity act in a "paradoxical" fashion when the movement is constrained or controlled (*Lombard's paradox*) (2). It was hypothesized that the BF was more active during ILP125 than during ILP90. The present results did not corroborate the main hypothesis that the BF was more active during ILP90 when compared with ILP125. The results showed that the BF activation was greater in ILP90 when compared with ILP125 in both analyses (peak RMS_{90}: 33% and iEMG: 23.7%). A possible

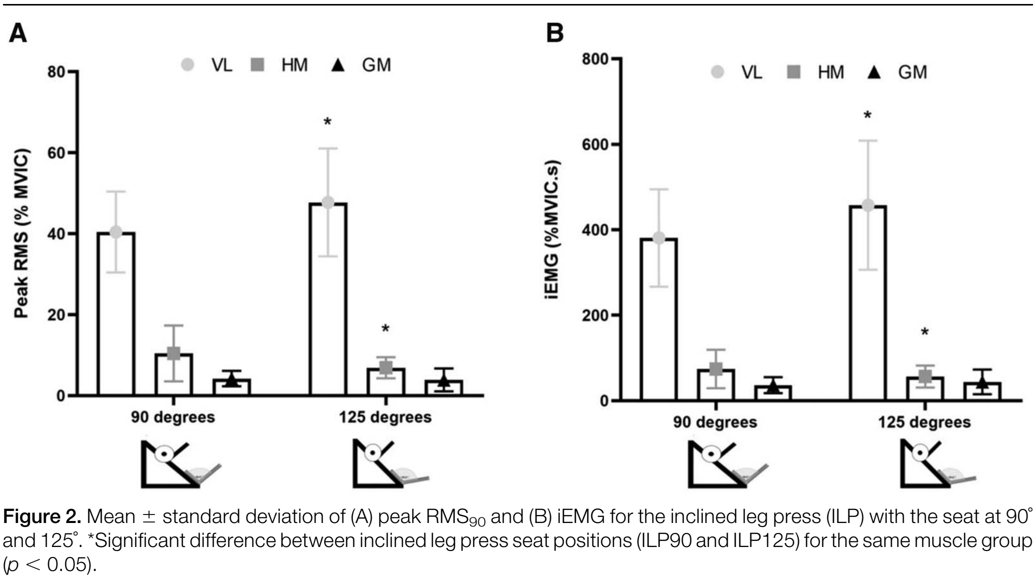

Figure 2. Mean ± standard deviation of (A) peak RMS_{90} and (B) iEMG for the inclined leg press (ILP) with the seat at 90° and 125°. *Significant difference between inclined leg press seat positions (ILP90 and ILP125) for the same muscle group ($p < 0.05$).

explanation for this difference would be the mechanical effect generated by the ILP90 condition, where the BF is more elongated as a function of the initial position of the hip joint. This more elongated position could affect the length-tension relationship of the muscle, in addition to being affected by the lumbar paradox, and therefore, present less myoelectric activity. In addition, the BF has a greater stabilizing role in the knee and hip joints than as a prime mover during ILP (14).

This study has some limitations that should be considered when interpreting the current results. We did not measure the ankle and hip joint angles during both experimental conditions. We analyzed both conditions (ILP125 and ILP90) in the same session with 30-minute rest between conditions, even not observing residual fatigue between the conditions. We also used healthy, recreationally trained men only, and, therefore, our findings are not generalizable to other conditions, populations, or women.

In conclusion, the myoelectric activation is affected by the angle between the seat and backrest for VL (ILP125 > ILP90) and BF (ILP90 > ILP125) with no difference for GM.

Practical Applications

The leg press is a multijoint exercise that activates VL, GM, and BF. However, the level of the myoelectric activity of the BF and GM was much lower when compared with VL. Therefore, when the objective of training or rehabilitation is to increase the myoelectric activity of the VL, it is recommended to incline the angle between the seat and backrest at 125°. This study shows that the leg press does not seem to be an efficient exercise in activating BF or GM. Therefore, other exercises should be added to the training program if these muscles are to be emphasized.

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The authors declare that they have no conflict of interest.

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