Relationship Between Gluteal Muscle Strength, Corticospinal Excitability, and Jump-Landing Biomechanics in Healthy Women

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Context: Components of gluteal neuromuscular function, such as strength and corticospinal excitability, could potentially influence alterations in lower extremity biomechanics during jump landing. Objective: To determine the relationship between gluteal muscle strength, gluteal corticospinal excitability, and jump-landing biomechanics in healthy women. Setting: University laboratory. Design: Descriptive laboratory study. Participants: 37 healthy women (21.08 ± 2.15 y, 164.8 ± 5.9 cm, 65.4 ± 12.0 kg). Interventions: Bilateral gluteal strength was assessed through maximal voluntary isometric contractions (MVIC) using an isokinetic dynamometer. Strength was tested in the open chain in prone and side-lying positions for the gluteus maximus and gluteus medius muscles, respectively. Transcranial magnetic stimulation was used to elicit measures of corticospinal excitability. Participants then performed 3 trials of jump landing from a 30-cm box to a distance of 50% of their height, with an immediate rebound to a maximal vertical jump. Each jump-landing trial was video recorded (2-D) and later scored for errors. Main Outcome Measures: MVICs normalized to body mass were used to assess strength in the gluteal muscles of the dominant and nondominant limbs. Corticospinal excitability was assessed by means of active motor threshold (AMT) and motor-evoked potentials (MEP) elicited at 120% of AMT. The Landing Error Scoring System (LESS) was used to evaluate jump-landing biomechanics. Results: A moderate, positive correlation was found between dominant gluteus maximus MEP and LESS scores ($r = .562, P = .029$). No other significant correlations were observed for MVIC, AMT, or MEP for the gluteus maximus and gluteus medius, regardless of limb. Conclusions: The findings suggest a moderate relationship between dominant gluteus maximus corticospinal excitability and a clinical measure of jump-landing biomechanics. Further research is required to substantiate the findings and expand our understanding of the central nervous system’s role in athletic movement.

Keywords: neural excitability, neuromuscular function, hip strength

Altered landing mechanics during a dynamic task, such as increased knee abduction or excessive knee-valgus angles, may predispose individuals to increased risk of lower extremity noncontact injury. Specifically, current prospective data suggest that dynamic knee-valgus angle during landing predicts future anterior cruciate ligament (ACL) rupture. In addition, ACL-reconstructed patients who present with smaller hip external-rotation moments during landing are 8 times more likely to suffer a second ACL rupture, demonstrating a potential inability to restrict excessive hip internal rotation. Further investigations have also shown an association between knee-valgus moments and hip internal rotation, hip adduction, and knee-flexion angles during dynamic tasks.

Muscles acting on the hip complex, specifically the gluteus medius and gluteus maximus, play a vital role in normal gait function and landing mechanics. During weight bearing, these muscles eccentrically contract to regulate the proximal component of dynamic knee valgus, such as internal rotation and adduction of the femur. Dysfunction of the gluteus maximus and gluteus medius, such as a decrease in activation, has been linked to lower extremity joint injuries, low back pain, altered posture, and neuromuscular inhibition of surrounding musculature. As a result, neuromuscular alterations in the gluteal musculature may lead to diminished neuromuscular control of the lower extremity, potentially resulting in undesirable kinematics and subsequent joint injury.

Adequate gluteal muscle strength could perceptibly dictate landing strategy in both healthy and pathological populations. Prospective research has suggested that strengthening hip external rotators, specifically the gluteus maximus, could limit the dynamic knee valgus observed before ACL injury. Furthermore, Heroux and Tremblay demonstrated that alterations in upstream neural motor-excitability pathways are present after

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ACL-reconstruction, specifically in the quadriceps muscles, suggesting that corticospinal excitability of muscles surrounding a joint may influence the biomechanics of common movements such as walking, jogging, or jumping. Corticospinal excitability can initiate motor-neuron activity during voluntary movement and can be modulated in response to afferent stimuli.12,13 During jump landing, individuals need to initiate muscle activity as they prepare for landing and subsequently respond to afferent stimuli such as landing surface or body position as they contact the landing surface. Therefore, it is plausible that variations in corticospinal excitability of the gluteal musculature could influence alterations in lower extremity joint kinematics during landing, potentially causing deleterious positioning of the lower extremity during landing.

The relationship between gluteal corticospinal excitability, strength, and landing biomechanics is currently unknown. Identifying factors associated with neuromuscular gluteal function and jump-landing biomechanics can aid in the development and optimization of future lower extremity injury-prevention and rehabilitation programs. To our knowledge, no previous investigation has examined corticospinal excitability in the gluteal musculature and, in particular, how corticospinal excitability relates to physical function. Therefore, the purpose of this investigation was to determine the relationship between gluteus maximus and gluteus medius strength, corticospinal excitability, and jump-landing biomechanics.

Methods

Design

This descriptive laboratory study assessed gluteus maximus and gluteus medius maximal voluntary isometric muscle strength, corticospinal excitability, and jump-landing biomechanics in a cohort of healthy women. We evaluated these measures in the dominant and nondominant limbs of all participants. Limb dominance was determined as the leg that each participant would use to kick a ball.

Participants

A total of 37 healthy and recreationally active women age 18 to 35 years volunteered to participate in this study. Female participants were used because this population more commonly presents with increased knee-valgus angles during jump-landing tasks and has been shown to be at a greater risk for ACL injury.14,15 Participants were excluded if they had any self-reported history of lower extremity orthopedic surgery, a history of any lower extremity ligamentous injury, or low back pain within the past 6 months. Due to corticospinal-excitability testing procedures, participants were also excluded if they had a history of a diagnosed heart condition that would preclude them from exercise, a history of a seizure or neurological disorder, or a history of a concussion in the past 6 months; if they were taking medication that may alter neural function, such as antidepressants or muscle relaxants; or if they had any history of brain cancer. Before enrollment, participants provided written informed consent approved by the institutional review board at the university.

Procedures

Strength Testing. Maximum voluntary isometric contractions (MVIC) were measured using a Biodex System II Pro dynamometer (Biodex Medical Systems, Shirley, NY) and a padded plinth. The order of muscle and limb tested was randomized during the session. Before testing, hip-joint positions were determined via handheld inclinometer. For gluteus maximus testing, participants were positioned prone with the testing limb in approximately 0° of hip extension (Figure 1). Participants were positioned side-lying on the untested limb, with the testing limb in approximately 10° of hip abduction for the gluteus medius assessment (Figure 2).16 During MVIC testing, the participant’s torso and contralateral limb were secured to the plinth with a nonelastic strap to limit movement of these segments. After 3 familiarization trials, participants performed 3 warm-up contractions at approximately 25%, 50%, and 75% of their MVIC based on their own judgment. After familiarization and warm-up, participants performed 3 MVICs for hip extension (gluteus maximus) and hip abduction (gluteus medius). To ensure maximal effort during MVIC testing, verbal encouragement was provided by the researcher and real-time visual feedback of the participant’s torque curve was provided via a custom computer software program (Microsoft Visual Basic, Redmond, WA).17 A minimum of 1 minute of rest was provided between MVICs, and the average of the 3 MVIC trials was used for analysis. Average MVIC values were then normalized to participant body mass (Nm/kg).

Corticospinal-Excitability Testing. Before testing, the gluteus maximus and gluteus medius muscle bellies of both limbs were debrided and prepared for electromyographic (EMG) electrode placement. Two 10-mm pregelled Ag/AgCl electrodes were positioned on the gluteal muscle bellies as previously reported.18,19 EMG signals were amplified with a gain of 1000 (EMG100C BIOPAC Systems Inc, Goleta, CA) before being digitally converted with a 16-bit data-acquisition system (MP150 BIOPAC Systems Inc). EMG signal was collected at 2 kHz with a common-mode rejection ratio of 110 dB, a noise voltage of 0.2 μV, and an input impedance of 1 MΩ. Transcranial magnetic stimulation (TMS) was used to elicit corticospinal excitability measures of interest, specifically active motor threshold (AMT) and motor-evoked potentials (MEP). During corticospinal-excitability testing, participants were positioned in the same manner as MVIC testing, with testing order of muscle and limb randomized. For testing of both the gluteus maximus and gluteus medius, a Lycra swim cap was placed on the participant’s head, and straight lines were drawn vertically on the swim cap from the center.
of the occiput to the nose and connecting the external auditory meatuses\textsuperscript{12,20} (Figure 3). Intersection of these lines, at the vertex of the skull, enabled identification of the approximate location of the motor cortex. A double-cone TMS coil (Magstim Company, Wales, UK) was positioned over the intersected lines, and beginning stimuli were given at 50\% of the maximal stimulator output to locate the optimal stimulating point and then moved 1 cm in an anteroposterior direction over the vertex of the cranium. The optimal stimulating point was defined as the optimal motor-cortex location producing the greatest muscle response visualized through EMG.\textsuperscript{20,21} Once this area was detected and marked on the swim cap, the simulator was secured.
over that spot using a flexible camera mount (Manfrotto Co, Cassola, Italy). Once the stimulator was secured in place, AMT was determined, which was defined as the lowest TMS intensity required to evoke a measurable (>100 μV) MEP in 5 out of 10 trials. Higher AMTs signify a decrease in corticospinal excitability, as more of a stimulus is needed to evoke a measurable response. Once AMT was established, 5 MEPs were evoked at an intensity of 120% of AMT, and the peak-to-peak EMG-amplitude values were averaged for the final analysis (Figure 4). Stimulator intensity was set at 120% of AMT due to parameters set by previous research and to prevent spread of stimulation into neighboring cortical regions. During testing, participants were directed to perform an isometric contraction of the testing limb at 5% of their MVIC for the muscle, maintaining this contraction while the stimulus was given. Visual feedback of the contraction torque was shown in real time on a custom computer software program (Microsoft Visual Basic, Redmond, WA) to control for variance. Between stimuli, the participants were allowed to relax.

It is important to note that outcome measures were not acquired for all participants due to safety requirements of TMS intensity. Precautionary measures of the equipment do not allow for stimulation above 70% of the maximum stimulator output (level 100); consequently, for participants whose AMT was >70, AMT could not be established, nor were MEPs measured at a corresponding percentage of 120% of AMT if that value was >70. For further analysis, participants were separated into 2 groups based on evaluation of corticospinal-excitability data. Participants were placed in group 1 if they failed to produce at least 1 AMT or MEP outcome measure in either muscle. Participants in group 2 were successfully evaluated for all corticospinal-excitability measures.

Jump-Landing Biomechanics

Jump-landing biomechanics were evaluated with the Landing Error Scoring System (LESS). Current research has demonstrated the LESS to be both a valid and reliable tool for quantifying errors identified in the biomechanics of jump landing, and it represents a clinically applicable assessment of landing. Two standard video cameras were positioned in the frontal and sagittal planes 3.5 m away from the landing area. Participants were instructed to jump forward off of a 30-cm box to a horizontal distance equal to 50% of their height. On ground impact, the participants immediately rebounded into a maximal vertical jump. After instruction, subjects were allowed to practice as many times as needed to familiarize themselves with the task, followed by a 1-minute rest. Three successful jumps, separated by 1-minute rests, were then recorded, and the criteria for a successful jump were as follows: jumping from the box with both feet, jumping forward but not vertically to reach landing area, and completing the task in a fluid motion. The 3 successful jumps were recorded and scored by 2 independent researchers who agreed on a final score. Higher LESS scores denote a greater number of errors during landing, representing poor landing mechanics. Total LESS scores can be assigned the categories of excellent, ≤4; good, >4 to ≤5; moderate, >5 to ≤6; and poor, >6, jump-landing biomechanics.

Statistical Analyses

Means and standard deviations were calculated for participant demographics. Six separate dependent t tests were used to determine if there were differences between dominant and nondominant limbs for all corticospinal-excitability and strength outcome measures. This statistical analysis allowed for evaluation between limbs due to the fact that the LESS is scored bilaterally. Separate Pearson product–moment correlations were calculated to assess the relationships between gluteal strength (MVIC) and corticospinal excitability (AMT; peak-to-peak MEP) of both the gluteus medius and the gluteus maximus of both limbs and LESS score. Correlational strength was
determined as strong (≥0.7), moderate (0.3–0.69), and weak (<0.3). Pearson product–moment correlations were calculated separately for dominant and nondominant limbs. To evaluate differences between group 1 (absence of 1 outcome measure of AMT or MEP data) and group 2 (all corticospinal measures), separate independent t tests were performed to determine differences in demographics, LESS score, and gluteal muscle strength. A priori levels of significance were set at \( P \leq 0.05 \).

## Results

A summary of participant demographics can be found in Table 1. Descriptive analysis of outcome measures can be found in Table 2, with each outcome associated with the appropriate sample size corresponding to the measures that could be recorded due to safety requirements. No statistical differences were found in MVIC, AMT, and MEP measures between dominant and nondominant limbs (Table 2). Our participants’ average LESS score of 4.8 demonstrates good jump-landing mechanics.

A moderate, positive correlation was found between dominant-side gluteus maximus MEP and LESS scores (\( r = 0.562, P = 0.029 \)). No other significant correlations were obtained for MVIC, AMT, or MEP for the gluteus maximus and gluteus medius, regardless of limb (Table 3). No differences were seen between groups in demographics, LESS score, or gluteal muscle strength (Table 4).

## Discussion

The purpose of this investigation was to determine the relationship between gluteal muscle strength, corticospinal excitability, and jump-landing biomechanics. Our

### Table 1 Subject Demographics, \( N = 37 \)

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>21.08 ± 2.15</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.8 ± 5.9</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>65.4 ± 12.0</td>
</tr>
<tr>
<td>Landing Error Scoring System score</td>
<td>4.8 ± 2.6</td>
</tr>
</tbody>
</table>

### Table 2 Means and Standard Deviations for Outcome Measures, Reported by Muscle and Limb

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Outcome measure</th>
<th>Dominant Mean ± SD</th>
<th>Dominant n</th>
<th>Nondominant Mean ± SD</th>
<th>Nondominant n</th>
<th>t test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gluteus maximus</td>
<td>MVIC</td>
<td>1.62 ± 0.45</td>
<td>37</td>
<td>1.47 ± 0.42</td>
<td>37</td>
<td>t(72) = 1.85, ( P = 0.07 )</td>
</tr>
<tr>
<td></td>
<td>AMT</td>
<td>51.5 ± 9.9</td>
<td>25</td>
<td>49.8 ± 12.2</td>
<td>17</td>
<td>t(40) = 0.37, ( P = 0.72 )</td>
</tr>
<tr>
<td></td>
<td>MEP</td>
<td>0.274 ± 0.263</td>
<td>15</td>
<td>0.244 ± 0.198</td>
<td>11</td>
<td>t(24) = 0.32, ( P = 0.75 )</td>
</tr>
<tr>
<td>Gluteus medius</td>
<td>MVIC</td>
<td>1.40 ± 0.46</td>
<td>37</td>
<td>1.35 ± 0.45</td>
<td>37</td>
<td>t(72) = 0.72, ( P = 0.48 )</td>
</tr>
<tr>
<td></td>
<td>AMT</td>
<td>49.2 ± 8.7</td>
<td>24</td>
<td>49.7 ± 10.3</td>
<td>23</td>
<td>t(45) = –0.32, ( P = 0.75 )</td>
</tr>
<tr>
<td></td>
<td>MEP</td>
<td>0.214 ± 0.064</td>
<td>15</td>
<td>0.211 ± 0.074</td>
<td>16</td>
<td>t(29) = 0.14, ( P = 0.89 )</td>
</tr>
</tbody>
</table>

Abbreviations: MVIC, maximal voluntary isometric contraction normalized to body weight (Nm/kg); AMT, active motor threshold; MEP, peak-to-peak motor-evoked potential at 120% of AMT.

### Table 3 Correlation Matrix Corresponding to LESS Scores

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Outcome measure</th>
<th>Dominant r</th>
<th>Dominant P</th>
<th>Nondominant r</th>
<th>Nondominant P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gluteus maximus</td>
<td>MVIC</td>
<td>–.044</td>
<td>.800</td>
<td>.106</td>
<td>.537</td>
</tr>
<tr>
<td></td>
<td>AMT</td>
<td>–.047</td>
<td>.827</td>
<td>.192</td>
<td>.477</td>
</tr>
<tr>
<td></td>
<td>MEP</td>
<td>.562</td>
<td>.029*</td>
<td>.326</td>
<td>.328</td>
</tr>
<tr>
<td>Gluteus medius</td>
<td>MVIC</td>
<td>.027</td>
<td>.877</td>
<td>–.033</td>
<td>.849</td>
</tr>
<tr>
<td></td>
<td>AMT</td>
<td>–.116</td>
<td>.597</td>
<td>.136</td>
<td>.546</td>
</tr>
<tr>
<td></td>
<td>MEP</td>
<td>.167</td>
<td>.552</td>
<td>–.366</td>
<td>.164</td>
</tr>
</tbody>
</table>

Abbreviations: MVIC, maximal voluntary isometric contraction; AMT, active motor threshold; MEP, motor-evoked potential at 120% of AMT.

*Significant at the \( P \leq .05 \) level.
results show minimal to no correlation between gluteal strength and measures of corticospinal excitability with the LESS, a clinical measure of jump-landing biomechanics. This suggests that strength and corticospinal excitability of the gluteus maximus and gluteus medius may not have an influence on healthy women’s LESS scores.

**Gluteal Muscle Strength and Landing Biomechanics**

During jump landing, increased dynamic knee valgus has been demonstrated to be a risk factor for acute knee injury, specifically of the ACL. The proximal component of dynamic knee valgus results from internal rotation and adduction of the femur, which are controlled by gluteus maximus and gluteus medius function. No differences were found between dominant- and nondominant-muscle strength of either the gluteus maximus or gluteus medius, which is consistent with previous research that demonstrated marginal strength differences (<4%) between limbs in healthy participants. We also found no significant relationship between maximal isometric gluteal strength and errors during dynamic jump-landing tasks, supporting previous findings. Our results are similar to those of previous investigations that found no significant correlations between gluteal muscle strength and lower extremity joint angles during a single-leg squat, lunge exercise, or drop-landing task. Although it is plausible that strength, as a gross measure of muscle function, would correlate with an individual’s landing mechanics, other neuromuscular factors may play a larger role in proper biomechanics during functional tasks, such as muscle timing and activation. It is important to note that this investigation used MVICs to measure strength. Isometric strength, specifically at 1 joint angle, may not be a comprehensive evaluation of muscle strength output and performance during functional activities. In addition, we assessed open-chain, concentric strength, whereas the gluteal musculature is primarily contracting eccentrically in a closed-chain position to prevent internal rotation and adduction of the femur during landing. Although an eccentric strength profile of these muscles may be more appropriate, possibly yielding a significant relationship, current evidence remains inconclusive.

**Corticospinal Excitability of the Gluteal Muscles and Landing Biomechanics**

Similar to gluteal strength, we did not find differences between dominant and nondominant corticospinal excitability of either the gluteus maximus or gluteus medius. Based on our correlational analysis, it does not appear that corticospinal excitability of the gluteal muscles influences landing biomechanics. To our knowledge, this is the first investigation to assess the effects of corticospinal excitability in the gluteal musculature. Corticospinal mechanisms have been thought to contribute to neuromuscular function, having the ability to respond to altered afferent inputs and adjust excitability after muscle training and various pathologies. Therefore, this pathway has the potential to drive motor function by initiating movement but also adapt to altered input allowing for modifications in the motor system. It is known that corticospinal pathways initiate motoneuron activity for voluntary movement, and although this pathway has been shown to have the capability to adjust its excitability in response to altered afferent signals, this system

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**Table 4 Comparison of Demographics, Landing Error Scoring System, and Strength Between Groups Based on Corticospinal-Excitability Data**

<table>
<thead>
<tr>
<th></th>
<th>Group 1a (n = 26)</th>
<th>Group 2b (n = 11)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>21.1 ± 2.6</td>
<td>21.0 ± 1.8</td>
<td>0.25</td>
<td>.80</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.8 ± 5.6</td>
<td>164.0 ± 6.1</td>
<td>1.41</td>
<td>.16</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>67.8 ± 10.5</td>
<td>64.1 ± 12.6</td>
<td>0.94</td>
<td>.35</td>
</tr>
<tr>
<td>Landing Error Scoring System</td>
<td>4.6 ± 2.6</td>
<td>4.8 ± 2.5</td>
<td>-0.16</td>
<td>.88</td>
</tr>
<tr>
<td>Dominant gluteus maximus MVIC (Nm/kg)</td>
<td>1.57 ± 0.34</td>
<td>1.69 ± 0.39</td>
<td>-0.93</td>
<td>.36</td>
</tr>
<tr>
<td>Dominant gluteus medius MVIC (Nm/kg)</td>
<td>1.35 ± 0.34</td>
<td>1.48 ± 0.42</td>
<td>-0.90</td>
<td>.37</td>
</tr>
<tr>
<td>Nondominant gluteus maximus MVIC (Nm/kg)</td>
<td>1.40 ± 0.30</td>
<td>1.56 ± 0.34</td>
<td>-1.32</td>
<td>.20</td>
</tr>
<tr>
<td>Nondominant gluteus medius MVIC (Nm/kg)</td>
<td>1.25 ± 0.32</td>
<td>1.44 ± 0.41</td>
<td>-1.34</td>
<td>.19</td>
</tr>
</tbody>
</table>

Abbreviations: MVIC, maximal voluntary isometric contraction.

a Participants with no data on active motor threshold or motor-evoked potential.

b Participants with all corticospinal data.
may lack the ability to correct undesirable kinematics in an immediate period of time, such as during a dynamic jump-landing task. Conversely, predetermined landing strategies controlled by corticospinal systems may not position the lower extremity in an optimal position to reduce the risk of joint injury. Therefore, clinicians may be able to identify individuals who exhibit poor landing biomechanics and employ interventions that target corticospinal systems, such as biofeedback, to correct hazardous joint positioning during jump landing. Furthermore, corticospinal pathways and learned motor patterns may provide commands for gross muscle movement while relying on sensory feedback to make adjustments. Therefore, individuals may depend on spinal-reflexive neural pathways to alter sudden movement patterns experienced during activity. However, more research is needed to understand the contribution of spinal-reflexive pathways to jump-landing strategies for common athletic movements. The LESS was used to assess error in landing biomechanics in this particular study, which is an activity that, when conducted in the laboratory, may not require much involvement from spinal reflexes.

Although the majority of our data suggest a lack of relationship overall, 1 potential association was discovered. A statistically significant positive correlation was found between MEP amplitude elicited at 120% of the AMT in the dominant gluteus maximus muscle and LESS scores. This implies that subjects with higher corticospinal excitability produce more errors when landing, representing poor biomechanics during this task. Although this 1 significant correlation should be viewed cautiously, as it may represent a spurious correlation based on the numerous correlational analyses conducted in this investigation, it is important to understand what this would signify clinically. Initially, one may infer that an increase in corticospinal excitability would improve neuromuscular function, leading to demonstration of proper biomechanics. However, it is also plausible that participants with poor jump-landing mechanics may require higher levels of corticospinal excitability to compensate for other musculoskeletal factors that affect neuromuscular control. It is important to note here that many other muscles in the lower extremity may affect dynamic knee valgus and therefore would also factor into LESS scores. Participants who demonstrate higher levels of corticospinal excitability in the gluteus maximus potentially demonstrate poor biomechanics because they are not relying on other muscles that limit excessive dynamic valgus, such as the quadriceps or hamstring muscle groups. An up-regulation of the gluteus maximus could result in a down-regulation of other muscles and could yield potentially hazardous biomechanics. This increase in corticospinal excitability could then be seen as inefficiency of the neuromuscular system and be considered poor neuromuscular control. As a result, these individuals may attempt to up-regulate corticospinal mechanisms (ie, allow excess corticospinal information to that muscle) to regulate optimal motor control. However, this significant correlation should still be viewed warily, with more research needed to determine the true relationship between gluteal corticospinal excitability and landing biomechanics.

Limitations

A limitation in this investigation was the inability to record outcome measures for all participants. Safety restrictions when using TMS prohibit stimulation above 70% of maximum intensity. Therefore, individuals who have the highest motor thresholds of >70 (denoting lower corticospinal excitability) may not have been captured in this study. However, at least 11 participants were able to be included in all analyses, and at least 15 participants, in all but 1 analysis (nondominant gluteus medius MEP). To our knowledge, this is the first investigation to use TMS to assess corticospinal excitability in the gluteal muscles. Therefore, we cannot make comparisons with previous work regarding the difficulty in eliciting these measures from these muscles. Further analysis was performed to help understand if potential differences exist in participants whose corticospinal excitability could not be established; however, no differences were observed between groups in demographics, LESS scores, or gluteal muscle strength. Other potential factors to consider may be subcutaneous fat when using surface electrodes or testing position (supine, side-lying, standing).

Another potential limitation in this study is the means by which corticospinal excitability was assessed. Although we found 1 measure of corticospinal excitability to correlate with landing mechanics (gluteus maximus MEP at 120% of AMT), these measures were assessed during a voluntary isometric contraction, instead of during the jump landing itself. Currently, methodological restrictions severely limit our ability to measure corticospinal excitability during dynamic activity. However, it would be ideal for investigators to understand how these pathways are reacting throughout the eccentric contractions during jump landing.

Finally, all of our participants were healthy women with overall jump-landing mechanics classified as good. Subsequent investigations may benefit from prescreening participants and enrolling individuals with a wide range of landing biomechanics, creating a stronger representative sample. However, using the LESS to assess biomechanics during the jump-landing task could possibly be a reason for the insignificant findings. Although the LESS is both a valid and a reliable tool for assessing gross motion during dynamic jump landing, this scoring system examines other characteristics of landing biomechanics that may not be associated with gluteal neuromuscular control, such as trunk lean and foot position. In addition, the LESS may not be sensitive enough to detect smaller biomechanical changes made through influences from corticospinal mechanisms. In future investigations, 3-dimensional motion-analysis testing could help determine if corticospinal excitability has influences on specific joint angles or moments, potentially stemming from more subtle adjustments in motor control during landing.
Conclusion

Our findings suggest a moderate relationship between dominant gluteus maximus corticospinal excitability and a clinical measure of jump-landing biomechanics. Further research is required to substantiate our findings and expand our understanding of other neuromuscular characteristics, including muscle strength and corticospinal excitability, that may affect jump-landing biomechanics.

References


