EFFECTS OF GLUTEUS MEDIUS STRENGTHENING EXERCISES ON HIP ABDUCTION/ADDUCTION STRENGTH RATIO IN ACTIVE ADULTS

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ABSTRACT

Menges LS, Haney DE, Krupnow AK, Larson AM, Winter CM, Janot JM. Effects of Gluteus Medius Strengthening Exercises on Hip Abduction Strength in Active Adults. Journal of Undergraduate Kinesiology Research; 10(1): 52-63. Purpose: Hip muscle weakness has been shown to be a major factor in lower extremity injuries. Specifically, cause for injury is seen with the inability of the gluteus medius (GM) to maintain proper tibiofemoral alignment during physical movements. Research evidence supports the use of a GM strengthening and a neuromuscular training program to decrease the risk of lower extremity injury. The purpose of this study was to determine the impact of isolation vs. movement-based exercise to increase GM strength and improve the balance between hip abductor (ABD) and adductor (ADD) strengths, as expressed in ratio of isokinetic hip ABD to ADD. Methods: Thirty-seven recreationally active individuals (18-29 years) participated in this study. Eight individuals were randomly selected to represent the control group who did not participate in a training regimen. Twenty-nine individuals were randomly assigned to either isolation (sidelying hip abduction) or movement-based (monster walks or banded squats) exercises. Each training group followed a 4-week program, following a protocol of two sets of ten repetitions, twice per week. All groups progressed in resistance based on subjective exertion based on Borg’s session RPE scale. Participants underwent pre and post testing to assess changes in the ABD/ADD strength ratio measured by the HUMAC NORM isokinetic machine. Results: A two-way repeated measures analysis of variance (RM ANOVA) indicated time (pretest, posttest) was a significant predictor of right ABD/ADD strength ratio, $F(1, 33) = 7.55, p = .01$. More specifically, right ABD/ADD
Gluteus Medius Strengthening

strength ratio significantly decreased from pre to post intervention. Training group was not a significant predictor of right ABD/ADD strength ratio. Another two-way repeated measures ANOVA indicated time and training group were not significant predictors of left ABD/ADD strength ratio, $F (1, 33) = 0.02, p = .89$, and $F (3, 33) = 1.18, p = .33$, respectively. In addition, no significant interaction effects were observed in the right and left ABD/ADD ratio, $F (3, 33) = 0.22, p = .88$ and $F (3, 33) = 0.86, p = .47$, respectively. **Conclusion:** The results suggest no significant difference in strength changes between isolation and movements based exercises in response to a 4-week GM strengthening intervention. Future research should implement the use of electromyography to monitor GM activation during exercise training in addition to applying measures of isometric and isokinetic strength as a method of pre and post testing.

**Key Words:** Hip Strengthening, Lower Extremity Injury, Recreationally Active Individuals, Neuromuscular Adaptations

**INTRODUCTION**

Some of the most prevalent overuse injuries in active individuals are iliotibial (IT) band syndrome, patellofemoral (PF) pain syndrome, and knee injuries (1). Generally, literature concludes that weakness in the hip and surrounding muscles leads to lower extremity injury (2-7). Specifically, the gluteus medius (GM) muscle and its role in hip abduction has been shown to be a primary factor in preventing lower extremity injuries (4, 6, 8). A strength training protocol targeting hip musculature, in particular the GM, reduces the risk of lower extremity injury in active individuals which emphasizes the need for a prehabilitation program, rather than a rehabilitation program (9). Though, research has shown the need for increases in GM Strength to decrease injury (2-8), literature has yet to conclude which exercises are the most effective for strengthening the GM. One direction is demonstrated through a study by Dierks et al. which points to the need to implement hip abduction strengthening programs to decrease the risk of knee pain by improving movement mechanics, meaning the additional strength may need to be tied to a movement pattern in order for the improvements in GM strength to be significant.

Exercises that seem to be consistently effective across various studies are the side-lying hip abduction and lateral band walks (Monster Walk) (10-13). In addition, placement of resistance bands and angle of lower extremity joints seem to have a marked impact on the effectiveness of some of these exercises (10). Due to variability between resistance used and other variations in exercise administration, some exercises have turned out to be more effective in some studies than in others, including single-leg squat and clam exercises (11-15). A commonality among these studies is that they all determined the exercise’s ability to strengthen the GM based on levels of activation recorded by electromyography. However, the articles comparing different exercises do not directly measure strength gains in the muscle following a training program. Inconclusive evidence justifies the need to further research which exercises are most effective for strengthening the GM muscle.
The prevalence of lower extremity injuries is established, along with the role the GM plays in the injury process. However, no previous research has established a definitive method to prevent these injuries through effective GM strengthening. Those that have attempted to isolate the GM activation measured by electromyography lacked evidence to suggest the actual strength gains from prescribed exercises.

Against this drawback, the purpose of this study is to determine the effectiveness of isolated or movement-based exercises on GM strength, as measured by the strength ratio of isokinetic hip abduction/adduction in recreationally active individuals. It is hypothesized that the results of the study will show that movement-based exercises elicit a greater increase in GM strength compared to isolated exercises.

METHODS

Subjects
Participants were recruited as a convenience sample via word of mouth and by a mass email to all kinesiology majors and minors at the University. After recruiting, 60 individuals were interested in participating and met the criteria. Of the 60 individuals, 37 participants completed the study. Exclusion criteria consisted of: 1) not meeting the definition of recreationally active, meaning exercising at least 150 minutes a week of moderate to vigorous intensity; 2) having a lower extremity injury with physical therapy rehabilitation in the last two years; and 3) participation in collegiate athletics. Participants were asked to maintain their current exercise routine. See Table 1 for demographic information. The Institutional Review Board reviewed and approved the study protocol. Each participant was explained the details of the study, including risks and benefits of the study. Prior to participation, each participant completed the informed consent form.

Table 1. Participant Demographic Information.

<table>
<thead>
<tr>
<th></th>
<th>Side-Lying Hip ABD (n=10)</th>
<th>Monster Walks (n=10)</th>
<th>Banded Squat (n=10)</th>
<th>Control (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>19.60 ± 1.58</td>
<td>19.70 ± 1.34</td>
<td>21.90 ± 0.57</td>
<td>22.00 ± 3.16</td>
</tr>
<tr>
<td>Height (in.)</td>
<td>65.88 ± 2.41</td>
<td>66.13 ± 3.25</td>
<td>65.75 ± 3.46</td>
<td>66.28 ± 4.52</td>
</tr>
<tr>
<td>Weight (lbs.)</td>
<td>150.20 ± 30.95</td>
<td>147.80 ± 25.83</td>
<td>137.80 ± 25.80</td>
<td>165.13 ± 33.06</td>
</tr>
<tr>
<td>PA Min (min.)</td>
<td>319.50 ± 118.00</td>
<td>305.00 ± 137.38</td>
<td>332.00 ± 321.21</td>
<td>198.75 ± 53.84</td>
</tr>
</tbody>
</table>

Sex
- Male 30% (n=3) 30% (n=3) 30% (n=3) 37.5% (n=3)
- Female 70% (n=7) 70% (n=7) 70% (n=7) 62.5% (n=5)

Type of Training
- Aerobic 0.0% (n=0) 10% (n=1) 0.0% (n=0) 25% (n=2)
- Resistance 10% (n=1) 10% (n=1) 20% (n=2) 0.0% (n=0)
- Both 90% (n=9) 80% (n=8) 80% (n=8) 75% (n=6)

Note: Continuous variables are reported in means ± standard deviations. ABD = Abduction. PA = Physical Activity.
Instrumentation

Strength. Relative gluteus medius (GM) strength was measured using an isokinetic dynamometer, the HUMAC NORM Testing and Rehabilitation System, Model 770 (16). To ensure reliability, the machine was operated according to the user's manual protocol for side-lying hip abduction/adduction at 60 degrees per second and all GM strength measures were collected by the same qualified investigators that went through six hours of training by a qualified instructor (16). An angular velocity of 60 degrees/second was chosen because in previous research it was found to elicit the highest values of peak torque among a range of 60 to 300 degrees/second (17). It addition, Pincivero, Lephart, and Karunakara have shown that test-retest reliability showed greater variability at higher velocities (300 degrees/second) compared to slower (60 degrees/second: standard errors of measurement range from 4.8 % to 11.6 %) giving greater reason to use a slower speed. (18). To further ensure reliability, each participant was given the same cues and level of external motivation. A level (Black & Decker) was used to determine a standard starting point at zero (neutral) angular position (Figure 1). A scale (Detecto) was used to obtain the participants' weights. Participants' height was measured using a stadiometer (SECA).

Strengthening Bands. Stretch Band Loops were utilized for the present study. There were three different levels including yellow (light), red (medium), and blue (heavy), which were used for progression of exercise. If further progression was necessary, combinations of bands were utilized in the following order: blue and yellow, blue and red, and blue and blue.

Procedures

Pretest. Data was collected over five consecutive days in the laboratory at the University. To prepare for the pretesting, the HUMAC NORM machine had to be set up appropriately to match the chosen test as seen described in the HUMAC NORM manual procedures for testing hip abduction and adduction (16). Each participant spent a total of 20 minutes to complete the testing. Individuals arrived and were given a questionnaire on injury history and physical activity levels, informed consent, and cover letter. Each form was discussed thoroughly, clarifying any questions addressed by participants. Upon completion of the informed consent, height (nearest quarter inch) and weight (nearest half pound) were measured and entered into the HUMAC NORM System. Individuals were asked to lie sidewise on the table facing away from the pivot arm (Figure 2). Researchers positioned the participant to standardize the test, lining up the gluteal fold with the thigh grab bar (Figure 3). Researchers then applied three stabilization belts over the participant to ensure no movement was allowed and that their hips stayed perpendicular to the table. Stabilization belts were firmly placed across the participant’s non-tested leg; attached to participant’s tested leg, just above the knee, to the pivot arm; and wrapped over the iliac crest (Figure 2). Using a level, the starting position was set at a zero (neutral) angular position (Figure 1). Ending position was established at the peak of his or her range of motion but not greater than 45 degrees (Figure 4). After the software was personalized to the participant, he or she was instructed to perform five practice repetitions (60 degrees/second) at maximum effort (Figure 4). Practice repetitions were performed to avoid a learning effect; the participant
was unaware that the first five repetitions were not recorded into the data set. The practice repetitions were followed by 20 seconds of rest. Immediately after the rest period, the individual was instructed to use maximal effort to complete five test repetitions (60 degrees/second). Exact procedure was completed on the opposite leg. The order of which each participant’s legs were tested was randomized. The main variable collected from the each testing session was the abduction/adduction (ABD/ADD) strength ratio, as a lower ABD/ADD ratio has been shown to increase the risk of lower extremity injuries, such as patellofemoral pain syndrome (19). After completion, the participant was told to expect an email about further instructions regarding the intervention. The participant was then dismissed.

Intervention. Thirty-seven participants were randomly organized into four groups: Control (n=8), Side-Lying Hip Abduction (n=10), Monster Walks (n=10), and Resistance Band Squats (n=9). Participants in Control group were instructed to continue current exercise routines. Participants in training groups all started at a yellow resistance band for standard resistance. During the 4-week training intervention, each participant was prescribed two sets of 10 repetitions for their assigned exercise. Participants performed these exercises two sessions per week for a total of eight sessions. Total time commitment by each participant averaged around 40 minutes over the 4-week intervention. Each session had to be separated by no less than 48 hours. On day one, participants were given specific exercise technique instruction and were also monitored each session to ensure proper form. Specific instructions provided for the Banded Squats were to place the band just under the knees, keep knees aligned over or slightly outside of the feet, and pause for one second at the bottom of the squat. Instructions for the Monster Walks included placing band around the balls of the feet, keeping toes pointing forward, maintaining slight bend in the knees and hips, and keeping tension on the band and moving at a controlled speed throughout the exercise. Side-Lying Hip Abduction instructions included lying with hips perpendicular to the ground, rotating hips so that the hip was internally rotated, and raising the leg laterally as high as the participant could while keeping it straight with a one second pause at the top. Participants progressed based on the Borg CR-10 RPE scale: 0 being resting and 10 being absolute maximal effort (20). RPE was based on the last two repetitions of the last set of exercises. Participants were progressed to a higher resistance the following session when RPE fell below 5.

Posttest. Procedures were identical to the pretest protocol. The only exception being that height was not re-measured. Individuals were told the real purpose of the study, told they would be given their results via e-mail in the future, and were then debriefed at the conclusion of the study.

Statistical Analyses
Data were analyzed using two-way repeated measures ANOVA (group x time). Significance level was set at .05. Software used to conduct the analyses was SPSS version 19.0.0; SPSS Inc., Chicago, IL.
RESULTS

Results are presented for 37 individuals who completed the study out of the original 38. The mean age of the participants was 20.7 ± 2.1 years. The reason one individual did not complete the intervention was illness unrelated to the study.

The two-way repeated measures ANOVA indicated time (pretest, posttest) was a significant predictor of right abduction/adduction (ABD/ADD) strength ratio, $F(1, 33) = 7.55$, $p = .01$. Across the four groups, right leg ABD/ADD ratio decreased, indicating that there was a decrease in ABD strength compared to ADD strength. Training group was not a significant predictor of right ABD/ADD strength ratio, $F(3, 33) = 0.46$, $p = .71$. In addition, no significant interaction effect was observed, $F(3, 33) = 0.22$, $p = .88$.

The two-way repeated measures ANOVA indicated time and training group were not significant predictors of left ABD/ADD strength ratio, $F(1, 33) = 0.02$, $p = .89$, and $F(3, 33) = 1.18$, $p = .33$, respectively. In addition, no significant interaction effect was observed, $F(3, 33) = 0.86$, $p = .47$.

Table 2 and Table 3 show the ratio of hip ABD/ADD strength in the left and right legs, respectively. The two-way repeated measures ANOVA indicated that participants from all four groups (Control, Side-Lying Hip Abduction, Monster Walks, and Resistance Band Squats) combined did not demonstrate significant differences between pretest and posttest for the left leg ($p = .89$). However, there was a significant difference in ABD/ADD strength ratio between pretest and posttest for the right leg ($p = .01$), such that all groups showed a decrease in the ABD/ADD strength ratio for the right leg.
Table 2. Descriptive Statistics for Left Leg ABD/ADD Ratios between Pretest and Posttest for Side-Lying Hip ABD (n = 10), Monster Walks (n = 10), Banded Squat (n = 9), and Controls (n = 8).

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-Lying Hip ABD</td>
<td>Pretest</td>
<td>65.20</td>
<td>12.56</td>
<td>57.75</td>
<td>72.65</td>
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<tr>
<td></td>
<td>Posttest</td>
<td>67.30</td>
<td>14.20</td>
<td>59.58</td>
<td>75.03</td>
</tr>
<tr>
<td>Monster Walks</td>
<td>Pretest</td>
<td>60.50</td>
<td>11.80</td>
<td>53.05</td>
<td>67.95</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>57.70</td>
<td>11.49</td>
<td>49.98</td>
<td>65.43</td>
</tr>
<tr>
<td>Banded Squat</td>
<td>Pretest</td>
<td>57.44</td>
<td>10.90</td>
<td>49.59</td>
<td>65.30</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>60.11</td>
<td>13.69</td>
<td>51.97</td>
<td>68.25</td>
</tr>
<tr>
<td>Control</td>
<td>Pretest</td>
<td>59.88</td>
<td>10.71</td>
<td>51.55</td>
<td>68.21</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>57.00</td>
<td>6.05</td>
<td>48.36</td>
<td>65.64</td>
</tr>
</tbody>
</table>

Note: ABD = abduction.

Table 3. Descriptive Statistics for Right Leg ABD/ADD Ratios between Pretest and Posttest for Side-Lying Hip ABD (n = 10), Monster Walks (n = 10), Banded Squat (n = 9), and Controls (n = 8).

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-Lying Hip ABD</td>
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<td>61.20</td>
<td>12.42</td>
<td>53.05</td>
<td>69.35</td>
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<tr>
<td></td>
<td>Posttest</td>
<td>54.20</td>
<td>10.54</td>
<td>47.00</td>
<td>61.40</td>
</tr>
<tr>
<td>Monster Walks</td>
<td>Pretest</td>
<td>56.80</td>
<td>13.76</td>
<td>48.65</td>
<td>64.95</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>53.10</td>
<td>11.69</td>
<td>45.90</td>
<td>60.30</td>
</tr>
<tr>
<td>Banded Squat</td>
<td>Pretest</td>
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<td>11.61</td>
<td>46.41</td>
<td>63.59</td>
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<tr>
<td></td>
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<tr>
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<td>Pretest</td>
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<td>12.69</td>
<td>50.51</td>
<td>68.74</td>
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<tr>
<td></td>
<td>Posttest</td>
<td>56.00</td>
<td>8.65</td>
<td>47.95</td>
<td>64.05</td>
</tr>
</tbody>
</table>

Note: ABD = abduction.
DISCUSSION

It was hypothesized that Banded Squats would be the most effective mechanism for increasing GM strength measured by isokinetic hip abduction in comparison to Side-Lying Hip Abduction, Monster Walks, and Control group. Banded squat was predicted to be most effective because performing a body squat is a fundamental movement where the "knee valgus" dysfunction (which indicates poor glut medius activation that results in tibiofemoral malalignment) is commonly seen (21). The banded squat includes both resistance training (to strengthen the gluteus medius) and movement pattern training, which Dierks and colleagues (2014) indicated would be needed in order to make the improved strength usable strength (2). However, among the four groups, the analysis showed no significant differences in GM strength after the 4-week intervention. Participants met twice a week to perform two sets of ten repetitions per session for the assigned group exercise.

The current study showed that a decrease in the ABD/ADD strength ratio was seen in only the right limb, which was every participant’s plant foot. This indicates that during both isolation and movement-based training, the non-plant foot may not be as engaged as the plant foot. Proper cueing and, if available, electromyography (EMG) monitoring during the training sessions should be implemented to ensure equal engagement of the GM in both lower limbs. As suggested by Fletcher and Long (2013), it is important to address muscle engagement differences between plant and non-plant limbs (22).

Other studies that used EMG measures showed greater GM activation while using the same exercises included in the current study (10,11,13). However, increased activation of the GM muscle may not actually lead to greater strength in isokinetic hip ABD, as shown in the present results. In addition, previous studies have correlated GM weakness with increased risk of lower extremity injury and have also recommended GM strengthening to decrease this risk (8). Since GM strengthening programs aim to improve mechanics for the purpose of injury prevention, looking at specific biomechanical improvements may have shown a training affect in addition to strength testing alone. A possible explanation for the lack of increase in hip ABD strength might be due to an increase in GM activation with a decrease in tensor fasciae latae (TFL) activation (23). While this change in activation from TFL to GM may decrease injury risk, it may also lead to overall reduction in strength of the movement due to altered muscle recruitment.

What might be more important to look at than just GM strength gains, is the balance between ABD and ADD strength. It has been shown that a smaller ABD/ADD strength ratio is correlated with an increase in the risk of lower extremity injury, such as patellofemoral pain syndrome (19). Therefore, exercises that cause an increase in the ABD/ADD strength ratio would be considered effective for decreasing the risk of lower extremity injury. Although the increases in ABD/ADD ratio for Side-Lying Hip Abduction and Banded Squat in the left limb were not significant, improvements were seen. This may indicate that an intervention greater than four weeks may be necessary for a significant increase in ABD/ADD ratio for the plant limb.
Lower extremity injury among recreationally active adults is primarily related to the inability to maintain proper alignment between the femur and the tibia. This is commonly referred to as valgus motion or hip abduction. The GM plays a role in maintaining proper alignment, reducing valgus motion (2,23). While improved GM strength or activation may improve mechanical alignment, it may not translate into actual hip abduction movement because its main purpose is to stabilize the hip in neutral position (2) rather than increasing ABD range of motion at the hip joint. Therefore, isometric strength at anatomical neutral may have been a more appropriate measure of the improvement in the GM’s ability to maintain tibiofemoral alignment in response to a strength intervention. This method was effective in a previous study that showed significant improvements in hip ABD strength following a 6-week intervention, utilizing isometric handheld dynamometer measurements (21).

Dierks and colleagues (2014) explain that GM weakness results in patellar maltracking, which can result in patellofemoral pain. The authors suggested that hip abduction strengthening programs may decrease the risk of patellofemoral pain by improving movement mechanics, but also noted that additional strength may need to be tied to a movement pattern in order to be effective (2). The similar effectiveness between movement-based and isolation exercises was found in the current study, providing rationale to use exercises related to desired movement patterns.

In addition to tracking isometric strength change, measuring muscular endurance may be more useful since many injuries, especially noted in runners, are due to easily fatigued GM muscles (2). When the GM becomes fatigued, the TFL has to activate more to compensate. Since the TFL is directly attached to the iliotibial (IT) band, increased activation causes greater stress on the IT band, which may lead to lower extremity injury, such as IT band syndrome (23).

Depending on the types of injury, specific neuromuscular training may also be needed in order to correct body/movement mechanics. A study by Willy and Davis (2011) performed a hip strengthening and movement education-training program consisting of single-leg squat training with neuromuscular re-education for proper mechanics. Although single-leg squat form improved, actual running form did not change after six weeks of training (21). This supports the need to focus on training the desired movement rather than just training strength of a specific muscle. Although there are no quantitative results to show improvements in our data, one participant noted following the Side-Lying Hip Abduction training that his squat form has improved and that he is better able to keep his knees from collapsing in (i.e. increased knee valgus) when ascending from deep squats.

A minimal duration and frequency was sought in order to elicit neuromuscular adaptations that would result in an increase in GM function. Although GM activation may have improved, muscle endurance needs to be addressed in order to prevent TFL activation and knee valgus when fatigued (2). In order to elicit improvements in GM endurance, and greater total volume may need to be utilized. A six-week training
program meeting three times per week was found to elicit positive changes in muscular strength and endurance (21).

**Strengths and Limitations**
This study is unique in that the focus was not strictly on the individual GM strength gain, but on the balance between the two muscle groups that keep proper lower extremity movement patterns/mechanics to minimize acute and/or chronic lower extremity injuries among non-injured recreationally active adults.

One limitation of the current study is that muscle activation via EMG was not assessed. A study by Kwak and colleagues (2000) showed the need to focus on maximizing GM activation with minimal TFL activation (23). Although the TFL participates in hip abduction, over activation of this muscle may result in IT band syndrome (23). Particularly for the right leg in our data, the mechanism of decreased ABD/ADD strength ratio was difficult to be explained. Therefore, in addition to the use of isokinetic measurements, having access to the EMG could have helped to assess the amount of muscle activation following the intervention. Further limitations include having a small sample size and minimal treatment durations that may not have been long enough to elicit significant neuromuscular adaptations.

**CONCLUSIONS AND FUTURE DIRECTIONS**
In conclusion, following a 4-week intervention, there was no significant improvement in GM strength using movement-based and isolation exercises in recreationally active adults. Regardless, movement-based exercises produced similar results as isolation exercises. Future research in this field of study is needed to examine factors, in addition to other testing modes such as hip abduction strength, which can be manipulated to decrease lower extremity injury risk. EMG and isometric measure of hip strength should be utilized to better assess GM activation and strength increases.

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