



# Looped Band Placed Around Thighs Increases EMG of Gluteal Muscles Without Hindering Performance During Squatting

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**Background:** There is little information about the effects of placing a resistance band around the outer thighs on the amplitude of performance and electromyography (EMG) of lower body muscles during a free barbell back squat (FBBS) activity. This study quantified EMG amplitudes of the gluteus medius, gluteus maximus, vastus lateralis, and biceps femoris during an FBBS with and without the use of a looped resistance band. In addition, the effects of the looped band on the number of repetitions completed on failure in performing FBBS were measured at 2 intensities.

**Methods:** In this study, 15 resistance-trained males (age,  $23.6 \pm 3.5$  years) completed an FBBS 3 repetition maximum (RM) test on the first testing day to estimate their 1RM. On days 2 and 3, participants completed 5 repetitions equal to 80% of their estimated 1RM followed by a repetition to failure test using 60% of estimated 1RM with and without a band placed around their thighs in a counter-balanced fashion while EMG amplitudes were collected.

**Results:** No differences were found at 60% intensity test between conditions (band:  $21.4 \pm 6$ , control:  $20.4 \pm 4.7$ ;  $P = .171$ ). Similarly, no differences were found between conditions in EMG of the vastus lateralis or biceps femoris at both intensities (effect size [ES] range = 0.01–0.4,  $P \geq .05$ ). In contrast, other than a few exceptions, gluteus medius and maximus showed greater EMG activity in the looped-band condition during tests (ES range = 0.28–1.15,  $P < .05$ ) at both 60% and 80% intensities.

**Conclusion:** Placing a looped resistance band around the thighs can be used as a training strategy to increase the activation of the hip muscles during FBBS using medium to heavy loads without negatively affecting performance.

**Keywords:** Loop band; squat; resistance training; electromyography

**Key Point:** Using a looped band around the distal thigh during a barbell squat activity increases EMG amplitude of the gluteal muscles

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## INTRODUCTION

The free barbell back squat (FBBS) is a widely practiced version of the loaded squat.<sup>1,2</sup> It is strongly correlated with various sport performance measures such as vertical jumps and sprints,<sup>3,4</sup> and it is commonly prescribed by exercise professionals to enhance sport performance.<sup>5,6</sup> Because it is such an effective exercise, both strength and conditioning and rehabilitation professionals are continually searching for technical or external aids to help increase squatting proficiency. One possible training strategy includes the placement of resistance bands or looped elastic tubing modalities around different aspects of the lower limbs (feet/ankles/distal-lateral thighs).<sup>7-10</sup> The looped band can act as proprioceptive aid that may influence lower body alignment,<sup>10,11</sup> electromyography (EMG) amplitudes,<sup>7,8</sup> and athletic performance. Hence, given its growing popularity, ease of use, low cost, and potential impact on some variables, investigating its effects is important.

Placing a looped band around the lower limbs is hypothesized to act as a proprioceptive aid, encouraging trainees to abduct the femur and avoid subsequent medial knee collapse.<sup>10,11</sup> Recently, it was shown that resistance bands placed around the lower body did not promote “neutral” knee alignment during squatting and jumping exercises.<sup>7,9</sup> The lack of effects in these studies may stem from the limited feedback participants received, their training status, or the location and resistance level of the bands. Placing an elastic band around the lower limbs has been shown to increase hip muscle EMG amplitudes during various lower body exercises.<sup>7,8</sup> Hip adduction and subsequent internal rotation is linked to patellofemoral pain syndrome<sup>12</sup> and non-contact anterior cruciate ligament injuries<sup>13,14</sup>; thus, increasing the contribution of the hip external rotators and abductors may assist in countering these movements.<sup>15,16</sup> However, despite the growing body of research, it remains unknown how placing a looped band around the distal thighs will

influence EMG amplitude of lower body muscle groups during high-intensity/high-load exercises. In most studies investigating the effects of a resistance band placed around the lower body, the outcome measures were unloaded jumps and low-load/low-intensity exercises.<sup>7,8</sup> Furthermore, a looped band may also influence performance measures (number of repetitions). To date, the effects of looped bands were only investigated in relation to EMG and mechanical alignment.

The purpose of this investigation was 2-fold. The first goal was to examine the effects of placing looped resistance bands around the distal-lateral portion of the thigh, on EMG amplitudes of the thigh, and on posterior hip muscle groups during high- and moderate-intensity FBBS among resistance-trained participants. The second goal was to examine the effect of looped resistance bands on FBBS performance at moderate resistance.

## METHODS

In this study 15 male participants (mean age,  $23.7 \pm 3.5$  years; height,  $180 \pm 8.3$  cm; weight  $86.1 \pm 10.2$  kg) possessing  $6.2 \pm 4.6$  years of FBBS experience volunteered to participate in the study. Participants were verbally informed of all procedures and they signed a written consent form. The Interdisciplinary Committee on Ethics in Human Research of the Memorial University of Newfoundland approved this study (ICEHR #20141327-HK), and this study was conducted in accordance with the Tri-Council Guideline in Canada with full disclosure of potential risks to participants.

Participants were required to visit the laboratory on the following 3 occasions: introductory, control, and experimental conditions. All sessions were separated by a minimum of 3 days, and a maximum of 7 days. The completion of the experimental and control days was counter-balanced and randomized for all participants. During the introductory session, participants were given a verbal explanation on what to expect during the study and were

given a consent form to read and sign. Participants' age, height, weight, and years of experience doing FBBS were recorded. An electronic goniometer was positioned on the lateral axis of the knee to ensure the knee reached a minimum of 90°. Once the 90° squat was determined, variable risers were placed to that height as a guide to ensure that participants achieved this depth with each repetition. Participants were instructed to only lightly touch, rather than completely sit on, the risers. A metronome set to 50 beats/min was used to control the tempo during descent and ascent phases of the squat. To find each individual's 3 repetition maximum (RM) on the first day, participants were allowed to warm-up with as much weight and sets as needed to accommodate the training status of each individual. The 3RM was used to predict their 1RM, which was then used to calculate each participant's 80% and 60% of predictive 1RM for subsequent testing days. A tape was placed on the floor, tracing the outer edge of the feet to control for feet positioning and width of stance between sessions (Figure 1). The investigator used verbal commands to instruct each participant to descend and ascend in a similar fashion on all testing days. See Figure 2 for an example of a FBBS performed during the experiment.

For the control and experimental sessions, participants performed maximum voluntary contraction (MVC) testing at the beginning of each session to normalize the EMG measures each day. Skin preparation for EMG electrodes included hair removal, dead epithelial cell removal, and cleansing. Indelible ink outlines were traced around the surface electrodes to ensure accurate repeated electrode placement between trials. Bipolar surface EMG electrodes were used to measure all EMG signals. Two surface EMG recording electrodes (disc-shaped, 10 mm in diameter; Meditrace Pellet Ag/AgCl electrodes, Graphic Controls Ltd., Buffalo, NY) were placed 2 cm apart on the dominant-leg vastus lateralis (VL), biceps femoris (BF), gluteus medius (GME), and gluteus maximus (GMA)



**Figure 1.** Control for width of stance and femur external rotation. Tape placed at the anterior and lateral aspects of the foot and marked for each individual participant. Participants were instructed to adjust their stance to this angle and width during each testing session.

muscle bellies, with a ground electrode placed on the fibular head. A tape was applied to the electrodes and leads to ensure optimal surface contact for the duration of the testing. All EMG activity was sampled at 2000 Hz, with a Blackman 61-dB band-pass filter between 10 and 500 Hz, amplified (bipolar differential



**Figure 2.** Experimental setup, posterior view. Placement of variable risers controlled for FBBS depth. All testing was completed within a closed squatting station, with safety bars set to applicable heights for each participant.



amplifier, input impedance = 2 M $\Omega$ , common mode rejection ratio of 110 dB min [50/60 Hz], gain at 1000, and analog-to-digitally converted [12 bit]). Raw data were stored on a personal computer for further analysis (Dell Inspiron 6000). A commercially available software program (AcqKnowledge 4.1, Biopac Systems Inc., Holliston, MA) was used to analyze the digitally converted analog data.

Participants performed two 3-second MVCs for the knee extensors, knee flexors, hip extensors and hip abductors to determine maximum EMG levels for each of the tested muscle group. For all MVCs, participants were instructed to contract the muscles as hard and as fast as possible, and were given strong verbal encouragement. Root mean square (RMS) EMG of all muscles was analyzed over a 1-second duration during the MVCs.

- **Knee Extension MVC:** Participants were seated in a specially designed chair (Technical Services, Memorial University, St. John's, NL, Canada) with the hips and knees secured at 90°. Bilateral shoulder straps linked with waist and groin straps ensured minimal body translation. A foam-padded strap was placed around the dominant leg at the ankle. The padded strap was secured by a wire connected to a metal brace located on the chair. Participants performed the isometric knee extension MVC by contracting the limb against the strap as hard as possible.
- **Knee flexion MVC:** From a standing position, participants stood with their hips placed at 0° and the dominant knee flexed to 90°. Participants performed the isometric MVC by pushing their dominant leg heel as hard as possible against an immovable metal bar.
- **Hip abduction MVC:** Participants were positioned on a bench, lying on the side contralateral to the dominant leg, with the hips and knees placed at 0°. Participants performed the isometric MVC by abducting their leg against an unmovable metal

bar. Participants performed the isometric hip abduction as hard as possible.

- **Hip extension MVC:** From a standing position, participants stood with their hips and knees at 0° and performed the isometric MVC by pushing the dominant leg heel against a wall. Participants performed the isometric hip extension as hard as possible.

After MVC testing on days 2 and 3, participants then completed a nonspecific, submaximal warm-up on a stationary bike at 70 RPM with one 1 KP resistance for 5 minutes. Participants then completed an exercise-specific warm-up, consisting of 1 set with a 20-kg bar followed by 2 sets of squats with a self-selected load. The self-selected warm-up completed on the day 1 of the experiment was repeated on day 2; thus, the number of sets, the number of repetitions, and the loads used during the warm-up were similar between the 2 testing sessions. This warm-up strategy was chosen to accommodate the training status of various participants and to increase the external validity of the study. After completing the last warm-up set, participants were given 5 minutes of rest before completing 5 repetitions using 80% of the estimated 1RM, after which they rested for additional 5 minutes and then completed 1 set to failure using 60% of the estimated 1RM (ie, inability to complete the next concentric contraction despite attempting to within the allocated time). Tensor bandages were wrapped around both thighs to ensure that electrodes would stay in place and ease the discomfort of wearing the looped band (Figure 3).

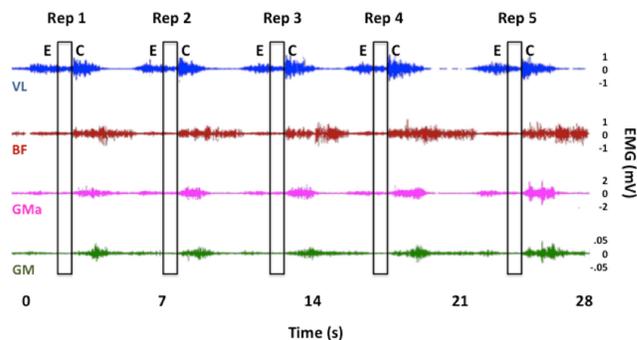
EMG amplitudes were measured during the squat protocols. Mean RMS of the VL, BF, GME, and GMA was analyzed over a window of EMG activity, which was then normalized to the MVCs conducted on that day. The EMG analysis was conducted for the first, third and fifth repetition for the 80% 1RM 5-repetition test; the first, middle (median), and last repetition were chosen for the 60% RM repetition to failure test. For



**Figure 3.** Experimental setup, anterior view. Placement of band and tensor bandage and EMG connected to the right thigh to avoid discomfort and keep electrodes in place.

example, if participants were able to complete 16 repetitions, the first, eighth, and sixteenth repetitions were analyzed. The EMG signal was first smoothed with a band-pass filter with a low frequency cutoff of 10 Hz and a high frequency cutoff of 500 Hz. RMS was derived from all signals with a time interval of 30 milliseconds. The highest peak to peak (P-P) value of each input of volts was found manually for both eccentric and concentric phases in each repetition. The mean RMS EMG from 250-millisecond pre-P-P value to 250-millisecond post-P-P value (total of 500 milliseconds in duration) was used for comparison. During the 60% RM test, the number of repetitions completed during the intervention versus that during the control session was used as a performance outcome of using the looped band. Figure 4 illustrates an example of raw EMG traces for each of the 4 muscles from 1 individual during the 5 repetitions using 80% of estimated 1RM.

Blue TheraBand<sup>®</sup> looped elastic bands (Performance Health, Akron, OH) were used to provide resistance for each participant. The bands used were categorized as “extra heavy,” had a diameter of 45.7 cm, and provided a resistance of 2.6 kg at 100% elongation. The bands were alternated during each intervention session. Before the study



**Figure 4.** 80% of estimated 1RM, raw data. Raw EMG data of the VL, BF, GMA, and GME. The letter E represents the eccentric phase, the hollow bar represents the holding phase at the terminal ROM, and C represents the concentric phase. X axis is time in seconds (s) and the Y axis is EMG output in millivolts (mV).

commenced, each band was pre-stretched to 25 cm and held at that length for 2 hours.

## Statistical Analysis

All statistical analyses were performed with SPSS (SPSS 18.0 for Macintosh, IBM Corporation, Armonk, New York). Paired *t* test was used to examine if a significant difference between conditions (looped band vs. no band) was found in the number of repetitions to failure in the 60% 1RM test to failure. A 2-way repeated-measures ANOVA (2 conditions [control and looped band] × repetition) was conducted to determine normalized EMG differences in the 80% 1RM 5-repetition test (first, third, and fifth repetition) and the 60% 1RM test to failure (first, middle, and last repetition) for the 4 tested muscles (VL, BF, GMA, and GME) and for each type of muscle contraction (concentric and eccentric). Paired *t* tests with Holmes–Bonferroni correction test were used to decompose significant interactions, and a post hoc Bonferroni was used to compare means if the main effects were found. Significance was set at  $P < .05$ . Cohen *d* effect sizes (ES)<sup>17</sup> were also calculated to compare the differences between conditions. All data are reported as means ± SD.



**Table 1.** Results of 5 repetitions using 80% of estimated 1RM

| <b>5 Reps Using 80% of Estimated 1RM</b> | <b>Control</b>                   | <b>Band</b>                      | <b>Differences Within Conditions</b>  | <b>Differences Between Conditions</b>   |
|--|----------------------------------|----------------------------------|---|---|
| VL CON 1,3,5                             | 104 ± 29<br>116 ± 32<br>114 ± 28 | 106 ± 24<br>108 ± 16<br>117 ± 20 | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.39; 10%)                             | No statistical or meaningful differences between conditions<br>(ES = 0.1–0.3; ~1%)                |
| BF CON 1,3,5                             | 45 ± 19<br>61 ± 22<br>69 ± 26    | 45 ± 19<br>61 ± 22<br>70 ± 26    | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.85; 22%)                             | No statistical or meaningful differences between conditions<br>(ES ≤ 0.1; ~1%)                    |
| GME CON 1,3,5                            | 41 ± 15<br>42 ± 13<br>51 ± 17    | 47 ± 23<br>60 ± 34*<br>67 ± 29*  | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.67; 14%)                             | Significant interaction ( $P < .05$ ). Greater ESs in band group<br>(ES = 0.66–67; 16%–18%)       |
| GMA CON 1,3,5                            | 56 ± 21<br>70 ± 30<br>71 ± 24    | 78 ± 19*<br>85 ± 32<br>103 ± 30* | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.72; 19%)                             | Significant interaction ( $P < .05$ ). Greater ESs in band condition<br>(ES = 0.8–1.15; 22%–32%)  |
| VL ECC 1,3,5                             | 69 ± 15<br>76 ± 12<br>78 ± 19    | 81 ± 28<br>84 ± 45<br>93 ± 37    | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.40; 10%)                             | No statistical difference but greater ESs in band condition<br>(ES = 0.24–0.53; ~8%–15%)          |
| BF ECC 1,3,5                             | 15 ± 9<br>16 ± 10<br>17 ± 11     | 14 ± 6<br>17 ± 8<br>18 ± 10      | No statistical or meaningful differences between reps 1 and 5 across conditions<br>(ES ≤ 0.27; ~3%) | No statistical or meaningful differences between conditions<br>(ES ≤ 0.13; ~1%)                   |
| GME ECC 1,3,5                            | 16 ± 8<br>16 ± 8<br>22 ± 14      | 21 ± 10<br>29 ± 17*<br>26 ± 14   | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.67; 14%)                             | Significant interaction ( $P < .05$ ). Greater ESs in band condition<br>(ES = 0.28–0.97; ~4%–13%) |
| GMA ECC 1,3,5                            | 22 ± 13<br>24 ± 12<br>28 ± 11    | 32 ± 15*<br>37 ± 15<br>35 ± 15   | Main effect ( $P < .05$ )<br>rep 1 lower than rep 5<br>(ES = 0.33; 5%)                              | Significant interaction ( $P < .05$ ). Greater ESs in band condition<br>(ES = 0.53–0.95; ~7%–13%) |

Notes: Data in the control and band columns represent means ± SD (% of MVC). VL: vastus lateralis, BF: biceps femoris, GME: gluteus medius, GMA: gluteus maximus, CON: concentric, ECC: eccentric, ES: effect size, rep: repetitions; \*significant difference between specific repetition.

**Table 2.** Results of repetitions to failure using 60% of estimated 1RM

| Reps to Failure Using 60% of Estimated 1RM |          |          | Differences Within Conditions   | Differences Between Conditions   |
|--|----------|----------|---|--|
|  | Control  | Band     |   |  |
| VL CON first, middle, last                 | 86 ± 22  | 91 ± 22  | Main effect ( $P < .05$ ) rep 1 lower than rep 5 across conditions (ES = 1.05; 24%)             | No statistical difference but possible greater ESs in band condition (ES = 0–0.24; ~0%–6%)     |
|  | 104 ± 24 | 110 ± 25 |   |  |
|  | 112 ± 22 | 112 ± 23 |   |  |
| BF CON first, middle, last                 | 35 ± 19  | 40 ± 17  | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 0.80; 21%)                               | No statistical or meaningful differences between conditions (ES ≤ 0.26; ~1%–6%)                |
|  | 56 ± 30  | 50 ± 19  |   |  |
|  | 57 ± 33  | 58 ± 30  |   |  |
| GME CON first, middle, last                | 27 ± 9   | 36 ± 19  | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 1.14; 23%)                               | No statistical difference but greater ESs in band condition (ES = 0.32–0.43; ~9%–19%)          |
|  | 37 ± 16  | 47 ± 23  |   |  |
|  | 44 ± 21  | 63 ± 28  |   |  |
| GMA CON first, middle, last                | 40 ± 21  | 61 ± 28* | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 1.34; 35%)                               | Significant interaction ( $P < .05$ ). Greater ESs in band condition (ES = 0.29–0.84; ~8%–21%) |
|  | 66 ± 26  | 74 ± 28  |   |  |
|  | 77 ± 20  | 92 ± 30  |   |  |
| VL ECC first, middle, last                 | 60 ± 15  | 67 ± 27  | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 0.62; 16%)                               | No statistical difference but greater ESs in band condition (ES = 0.32–0.43; ~7%–11%)          |
|  | 65 ± 18  | 74 ± 23  |   |  |
|  | 74 ± 13  | 85 ± 46  |   |  |
| BF ECC first, middle, last                 | 12 ± 8   | 13 ± 6   | No statistical differences between reps 1 and 5 across conditions but small ESs (ES = 0.4; ~5%) | No statistical or meaningful differences between conditions (ES ≤ 0.14; ~1%)                   |
|  | 18 ± 19  | 17 ± 12  |   |  |
|  | 17 ± 11  | 18 ± 11  |   |  |
| GME ECC first, middle, last                | 12 ± 5   | 20 ± 13  | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 0.84; 11%)                               | No statistical difference but greater ESs in band condition (ES = 0.32–1.03; ~8%–16%)          |
|  | 13 ± 6   | 25 ± 15  |   |  |
|  | 19 ± 10  | 35 ± 21  |   |  |
| GMA ECC first, middle, last                | 13 ± 8   | 21 ± 9   | Main effect ( $P < .05$ ) rep 1 lower than rep 5 (ES = 1.26; 18%)                               | Significant main effect ( $P < .05$ ). Greater ESs in band condition (ES = 0.82–0.93; ~8%–17%) |
|  | 19 ± 12  | 32 ± 16  |   |  |
|  | 27 ± 11  | 44 ± 27  |   |  |

Notes: Data in the control and band columns represents means ± SD (% of MVC). VL: vastus lateralis, BF: biceps femoris, GME: gluteus medius, GMA: gluteus maximus; CON: concentric, ECC: eccentric, ES: effect size, rep: repetition; \*significant difference between specific repetitions.

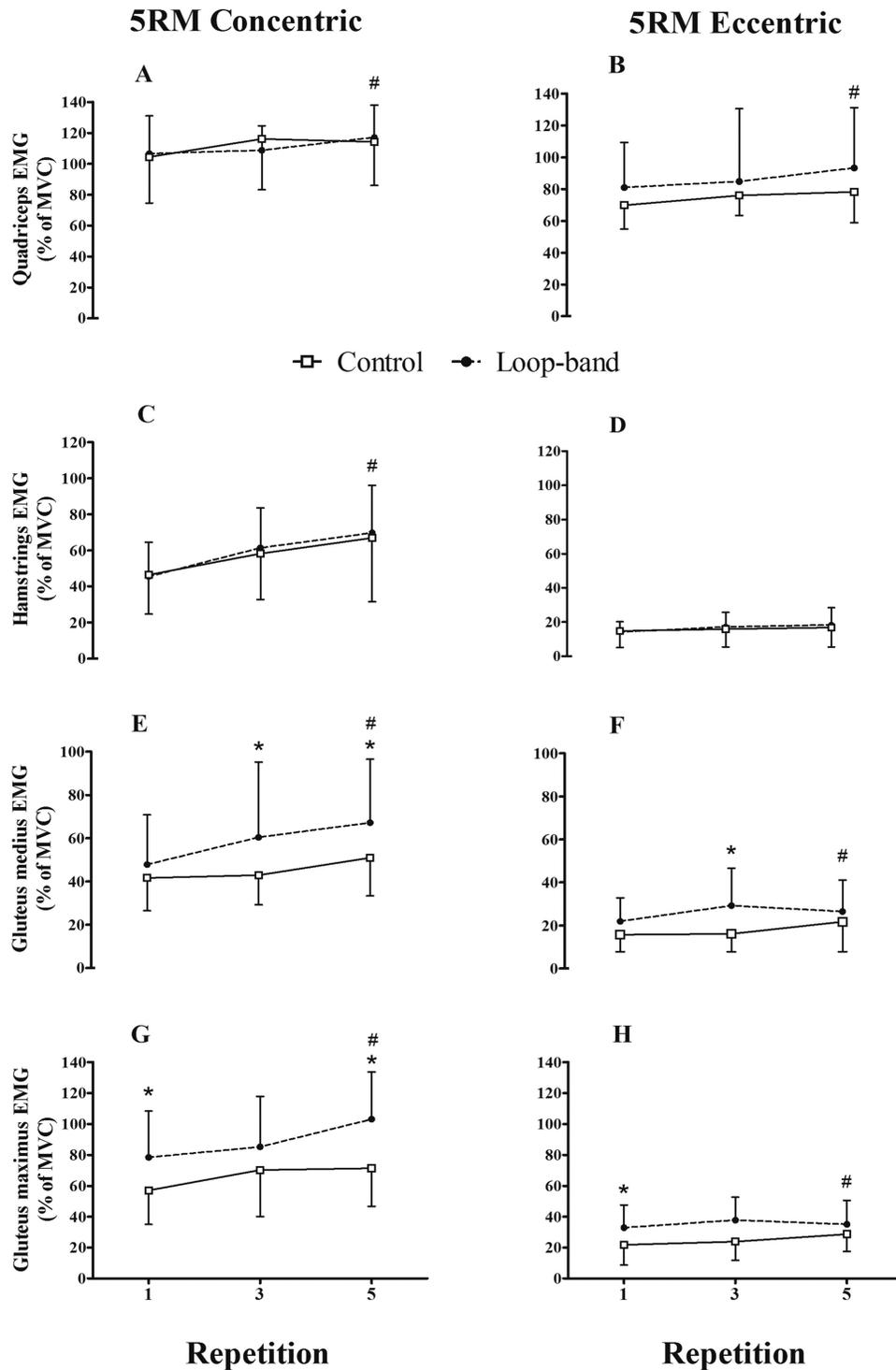
## RESULTS

### Number of Repetitions

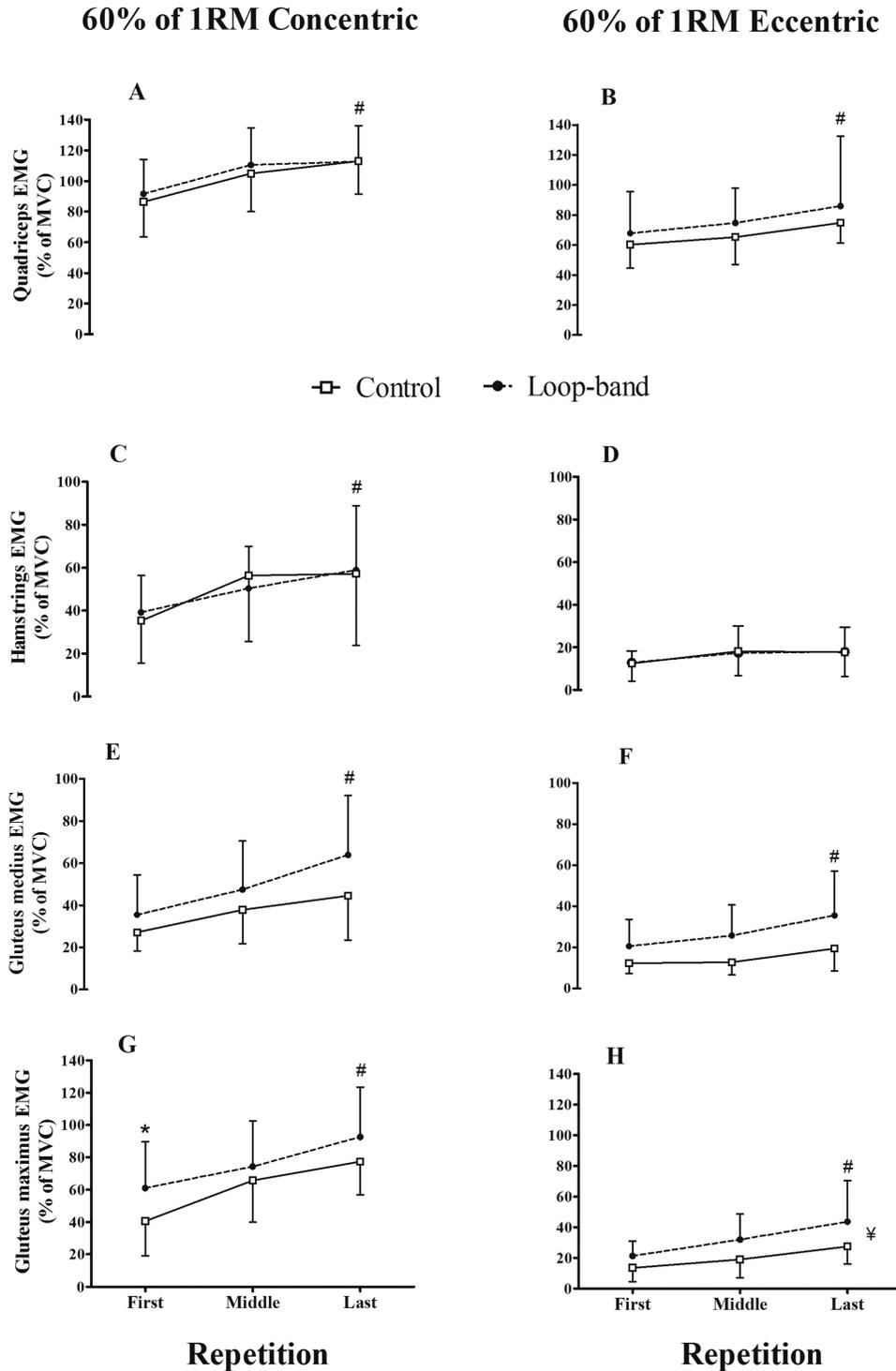
No significant difference was found in the number of repetitions to failure in the 60% 1RM test between conditions; however, participants were able to complete 1 more repetition in the looped-band condition ( $P = .171$ ; no band:  $20.4 \pm 4.7$ ; looped band:  $21.4 \pm 6$ ).

### EMG

Table 1 (5 repetitions using 80% of estimated 1RM) and Table 2 (repetitions to failure using 60% of estimated 1RM) summarize changes in EMG for all muscles between and within conditions. Changes in EMG for all muscles are also illustrated in Figure 5 (80% 1RM) and Figure 6 (60% 1RM).



**Figure 5.** Five repetitions using 80% of estimated 1RM. Average concentric EMG of first, median, and last repetitions of the VL (A), BF (C), GME (E), and GMA (G); average eccentric EMG of first, median, and last repetitions of the VL (B), BF (D), GME (F), and GMA (H). \*Represents significant difference between groups, #represents significant main effect for repetition number at  $P < .05$ . Data is represented as mean  $\pm$  SD.



**Figure 6.** 60% 1 RM, maximum repetition test. Average concentric EMG of first, median, and last repetitions of the VL (A), BF (C), GME (E), and GMA (G); Average eccentric EMG of first, median, and last repetitions of the VL (B), BF (D), GME (F), and GMA (H) (B). \*Represents significant difference between groups; #represents significant main effect for repetition number; and †represents significant main effect for group at  $P < .05$ . Data are represented as mean  $\pm$  SD.



## DISCUSSION

The goals of this study were 2-fold. The first was to investigate how placement of the TheraBand looped bands around the distal lateral thighs affects EMG amplitudes of various lower body muscles during moderate- and high-intensity FBBS among resistance-trained males. The second goal was to examine how the looped bands influence performance measured by the number of repetitions participants were able to complete using a submaximal load (60% estimated 1RM).

In agreement with previous literature,<sup>7,8</sup> greater EMG amplitudes of the gluteal muscles (both GME and GMA) were detected under the looped-band condition. We observed this in both the 5 repetitions at 80% of estimated 1RM and the repetitions to failure test at 60% of estimated 1RM during both the concentric and eccentric phases of the squat. The looped band-induced increase in GME during the squats may be due to increased stabilization of the pelvis and avoiding medial knee collapse,<sup>2,12</sup> and the increased GMA may contribute more to avoiding internal rotation of the hip.<sup>2,12</sup> In contrast, the quadriceps and hamstring muscle groups showed no meaningful change in EMG amplitudes when the looped band was applied. The increased EMG amplitudes of the gluteal muscles is somewhat expected given that the hip abductors are required to resist the forces created by the looped band.

Gooyers et al.<sup>9</sup> hypothesized that frontal knee plane mechanics remained unchanged in their study because unpublished findings from their laboratory indicated that the looped bands may have elicited greater activity in the lateral thigh muscles (VL) during squatting movements. The results from our study do not support this contention in a trained population, as the quadriceps did not show a significant change in EMG when the looped band was applied.

In general, all muscles showed a common trend: greater EMG amplitudes from the first,

to the middle, and to the last repetition, except for the eccentric contraction of the hamstrings during both the 5 repetitions using 80% of estimated 1RM and the repetitions to failure test using 60% of estimated 1RM. The increase in EMG amplitudes with increasing repetition number is typical during submaximal fatiguing contractions.<sup>18,19</sup> It may be that EMG amplitudes increased to sustain the required efforts: with each completed repetition, muscle fatigue develops for various central and peripheral nervous system reasons. EMG is a crude measure of central drive, as it is also influenced by peripheral factors.<sup>20</sup> However, the incremental increases in EMG found in this study could indicate increased central drive to overcome fatigue.<sup>18,19</sup>

Although the placement of the looped band considerably influenced EMG amplitudes during the repetitions to failure 60% of estimated 1RM test, it did not statistically influence the number of repetitions completed. However, on average, the number of repetitions completed by participants increased by 1 in the looped-band condition. Although this was not statistically significant, clinicians, coaches, and trainees in a real-world setting may want to incorporate this method to help athletes increase their repetition totals. To the best of our knowledge, this is the first study to investigate the effects of a looped band on performance rather than only EMG amplitudes and/or biomechanical alignment. Given the lack of negative, and even the potential positive effects, in conjunction with the increased EMG amplitudes, further research investigating the effects that looped bands have on performance is a worthwhile and interesting research avenue.

A number of difficulties were encountered in this study. First, some participants reported that the looped bands in this experiment were forceful and were apprehensive to use them during their first practice sets. However, tensor wraps were found to decrease the level of discomfort. Second, the placement of the looped band proved difficult to standardize on participants, as the looped band would not stay flattened against the participant's thighs, as it



would naturally follow the path of least resistance on the participants' legs. Developing technical strategies to assist in maintaining the looped band in a flattened position during a squat is warranted.

## Practical Implications

Coaches tend to focus on strengthening the hips of athletes who are involved in a wide range of athletic endeavors,<sup>2</sup> as it is generally believed the hip musculature plays an important role with regard to bettering one's overall performance and reducing injury rates.<sup>14,21</sup> Therefore, it is generally agreed that activating the hips to a greater extent can serve a dual purpose of increasing athletic performance and correcting dysfunction of the lower extremities. Coaches and trainers who program high-intensity squat training can also use the looped bands to activate the hip musculature to a greater degree knowing that it should not have a negative effect on performance.

## CONCLUSIONS

The findings suggest that looped bands around the distal lateral portion of the thigh lead to:

- increased EMG amplitude of the gluteal muscle group;
- no change in hamstring or quadriceps EMG amplitude; and
- no change in performance (but may have a small positive benefit).

Future efforts to examine the impact of looped bands around the distal thigh should focus on:

- biomechanical change on frontal knee plane mechanics in a trained population during high-intensity squatting; and
- the effect of the looped band on the FBBS at lower intensities in recreationally trained athletes from both a biomechanical and muscular perspective.

Recreational athletes could potentially have the greatest room for improvement in their squatting technique, as trained athletes have practiced and refined the squat to a greater degree.

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