MUSCLE ACTIVATION COMPARISON OF LEG PRESS AND BACK SQUAT BETWEEN MEN AND WOMEN

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The purpose of this study was to examine gender differences in relative muscle activation and strength for the leg press and back squat. Experienced lifters (10 women, 9 men) completed a wide and narrow variation of each lift at their 10RM. EMG for 10 muscles (relative to maximum isometric activation) was compared. There was a significant difference in absolute strength between genders, but no difference in relative strength. No differences in muscle activation were found between wide and narrow stances, although some muscles had greater activity in the squat than the leg press. The only gender difference was women having significantly higher vastus lateralis relative activation regardless of lift. Overall, men and women seem to be similar in both relative strength and muscle activation.

KEY WORDS: EMG, relative strength, stance width

INTRODUCTION: Research studies on women and resistance training are limited in number and when women are compared to men the results are sometimes contradicting. In absolute terms, men have consistently demonstrated higher muscular strength than women (Mayhew, et al., 1992), both pre- and post-training (Kell, 2011). With regard to relative strength, women have been found to be equal to men (Ebben & Jensen, 1998; Kell, 2011), but the findings are not as clear. Kell (2011) also found that for some lifts (e.g., back squat and bench press) there were no gender differences in relative strength, but for others (e.g., lateral pull-down and dumbbell shoulder press) men lifted significantly more than women. While relative strength comparisons of gender may be conflicting, many studies seem to focus instead on comparisons of changes in relative strength over time. Several researchers have shown men and women can achieve similar increases in relative strength following a training program (Abe et al., 1999; Kell, 2011; Hubal et al., 2005); some have speculated that the reason for this could be due to a lower initial strength in women (Hubal et al., 2005), unfamiliarity with the exercises (Kell, 2011), or hormonal effects (Kraemer et al., 1998; Linnamo et al., 2005).
Few other differences between men and women in resistance training have been examined. For example, no study has examined whether there are differences between the genders for muscle activation. While there are electromyographic (EMG) similarities and differences between leg press and back squat variations (Escamilla et al., 2001), it is not known if men and women differ in muscle recruitment for these exercises. Differences in relative strength and neuromuscular changes (Linnamo et al., 2005), as well as overall body structure could all have an impact on the use and reliance on certain muscles to complete a task. Therefore, EMG analysis could play a crucial role in determining differences in muscle activation between genders. The purpose of this study was to test whether relative strength or muscle activation differed across genders and between back squat and leg press variations.

METHODS: Nine male and ten female weight lifters experienced in the back squat and leg press served as subjects (age=20.25±1.59 years, height=1.70±0.09 m, weight= 73.02±14.55 kg, experience=4.5±2.5 years). All subjects were injury free for 6 months prior to participation. After providing informed consent, the ASIS distance was measured to control for stance width across subjects in all tests consistent with Escamilla et al. (2001). A 5 minute, medium intensity warm-up was performed on a stationary bicycle before any activity. During the first session, subjects completed a back squat and leg press 10 repetition maximum (10RM). For the 10RM, the stance for the back squat was halfway between the narrow stance (distance between both ASIS), and the wide stance (twice the distance between the ASIS). The feet were placed at 30° of forefoot abduction, consistent with

Escamilla et al. (2001). For the leg press (Samson, USA), these conditions were the same, but the feet were centered from top to bottom of the plate.

During the second session, one week later, EMG data was collected. After the skin was cleaned with sandpaper and alcohol to limit interference, electrodes were placed on the following muscles (right side of body) according to the recommendations of SENIAM: rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF), semitendinosus (ST), gastrocnemius (GC), gluteus maximus (GMX), gluteus medius (GMD), adductor magnus (AM), and transverse abdominis (TA). After electrode placement each subject completed the same warm-up as before. Then, maximum voluntary isometric contraction of each muscle was determined for data normalization; joint positions were based on Escamilla et al. (2001). In testing, the subject performed a wide stance leg press (WLP), narrow stance leg press (NLP), wide stance back squat (WSQ), and narrow stance back squat (NSQ) with the foot placement at 30° of forefoot abduction in a randomly determined order. The subject performed five repetitions of each exercise, each lift was completed with a similar ROM, indicated by maximal knee flexion of approximately 90°. The 10RM determined on the back squat and leg press was used for each variation of that exercise during data collection. Between each exercise variation, the subject rested until they reached full recovery (approximately 3-4 minutes), again consistent with Escamilla et al. (2001).

A Delsys Trigno system at a sampling rate of 1 kHz was used in data collection. Using EMGworks software, raw EMG signals were filtered and RMS processed. The average of the combined eccentric and concentric phases for the middle 3 repetitions was used for analysis. All EMG activity was analyzed relative to the maximum voluntary isometric contraction. T-tests were used to compare 10RM between absolute and relative squat and leg press performance. Relative lift performance was normalized to body mass. All four testing conditions were examined with a 4 (exercise) x 2 (gender) repeated measures ANOVA. When a significant main effect was found, Bonferroni post-hoc correction was used. All statistics used an alpha level of 0.05 and effect sizes were calculated using partial eta squared.

RESULTS: The absolute and relative resistance for each 10RM test is shown in Table 1. Men achieved a significantly higher ($p<0.05$) absolute 10RM for both the back squat and leg press, but no difference between genders for relative 10RM was found. Relative muscle activity by condition is shown in Table 2.

Table 1. Mean (±SD) absolute and relative back squat and leg press performance for men and women, absolute values are significantly different ($p<0.05$), relative values are not.

	Squat 10RM (kg)	Leg Press 10RM (kg)	Relative Squat 10RM (%)	Relative Leg Press 10RM (%)
Women	63.6±17.0	115.9±30.6	103±32	188±61
Men	97.3±22.4	198.6±51.1	119±31	239±52

No differences in relative muscle activation were found for the different stance widths. Several muscles had significantly higher relative muscle activation in the back squat than in the leg press (see Table 2). Women had significantly greater ($p<0.05$) relative muscle activation than men only for the VL; No interaction effect between conditions or gender was found (see Figure 1). No other muscles differed between genders.

Table 2. Mean (±SD) relative muscle activity for each condition. Significant main effect differences for lift are shown with letter superscripts; no letters are shown when means are not different. A * indicates significant main effect for lift, but no post-hoc differences.

Muscle	WLP (%)	NLP (%)	WSQ (%)	NSQ (%)
TA	15.4±14.0[a]	13.1±14.0	26.3±17.0[b]	26.6±17.0[b]
VM	71.1±22.4	69.8±18.1	79.1±36.1	78.6±28.8
RF	88.9±57.5	78.0±31.6	91.7±34.5	92.6±38.0
VL*	71.3±19.3	68.9±18.79	82.4±29.3	80.9±26.8
GMD	13.9±6.5[a]	15.9±8.1[a]	30.0±13.2[b]	27.3±12.1[b]
GMX	59.8±31.7[a]	62.8±30.0[a]	162.7±103.0[b]	149.1±87.2[b]
BF	25.3±19.3	23.5±16.2	30.9±21.2	29.2±19.2
ST	16.7±11.0[a]	16.3±12.3[a]	28.1±14.6[b]	24.4±12.9[b]
AM	61.6±25.9	51.1±20.6	51.8±21.9	50.0±18.7
GC*	74.0±48.4	68.2±36.9	95.7±34.1	92.4±33.9

Note. Wide leg press (WLP), narrow leg press (NLP), wide squat (WSQ), & narrow squat (NSQ)

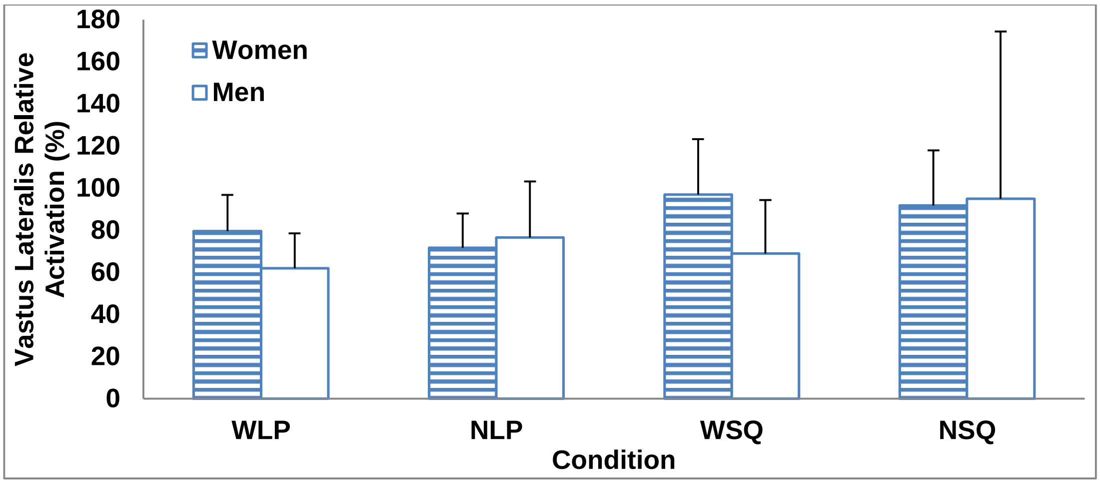

Figure 1. Mean (±SD) for relative vastus lateralis activation for men and women. Women had significantly higher activation for this muscle than men ($p<0.05$) with no interaction effect between conditions and gender Note: Wide leg press (WLP), narrow leg press (NLP), wide squat (WSQ), & narrow squat (NSQ).

DISCUSSION: For both the leg press and back squat, the significantly greater absolute strength of men mirrored the findings of other studies (Kell, 2011; Mayhew et al., 1992). However, in relative measures of strength, women and men were not significantly different. This supports some research (Ebben & Jensen, 1998; Kell, 2011) but not others (Kell, 2011; Miller et al., 1993).

When comparing muscle activity at different stance widths, Escamilla et al. (2001) found the narrow squat to have higher relative activation for the gastrocnemius and the wide leg press to have greater activation for the hamstrings group. We found no differences for different stance widths for any muscle. This was most surprising for the AM because it was expected that its role in hip adduction would necessitate greater activation in the wider stance. Perhaps the submaximal 10RM resistance was too low to elicit a response in this muscle. Irrespective of stance width, there were some relative muscle activation differences between the back squat and leg press lifts. Although no relative activation differences were found between lifts for the VM, RF, BF and AM, back squat conditions had significantly higher relative muscle activation than leg press for the TA, VL, GMD, GMX, ST, and GC. Moderate effect sizes were found (0.44-0.61) for the TA, GMD, GMX, and ST. Except for the TA, both leg press lifts had significantly less relative EMG activity than the back squat lifts. For the TA, the NLP had significantly less activity than the squat lifts, but not the WLP. The VL and the GC had small effect sizes (0.24 and 0.21, respectively), and may explain why no significant differences were found in the post-hoc tests. Even though the leg press lifts were higher weights than the

back squat, the greater activation levels in the squat may be because it requires the lifter to support his or her own body weight to a greater degree than leg press.
For the comparison of gender, only the VL had any significant differences, with women having significantly higher relative EMG than the men. The effect size was small (0.29) and may indicate a random finding rather than one that may be repeated. While EMG activation does not seem to differ for men and women across lifts when comparing similar relative loads, there could still be other technique differences in how men and women accomplish these lifts. There may be differences in muscle coordination or segmental coordination that were not examined here.

CONCLUSIONS: Within the limitations of this study, men and women seem to have similar relative strength for the leg press and back squat. For a submaximal 10RM, no differences in muscle activation were found with different stance widths. Muscle activation for TA, GMD, GMX, and VL were higher for the squat lifts, perhaps due to greater degrees of freedom in the squat lifts. Men and women do not seem to differ regarding relative muscle activation for the leg press and squats. The implications are that no additional training or accommodation will be needed for women or men with respect to muscle activation in these lifts.

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