IMPROVED MUSCLE ACTIVATION IN PERFORMING A BODY WEIGHT LUNGE COMPARED TO THE TRADITIONAL BACK SQUAT

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The purpose of this study was to examine the muscle activity during the body weight lunge and back squat at three depths, 90°, 60°, and 30°. Eight female collegiate athletes volunteered for the study. Each participant performed 5 squats at each depth and the body weight lunge. Surface EMG data and video were recorded to analyze the motion. The lunge activated most of the lower muscles greater than the squat. Sport performance is often initiated from a ready stance, similar to that of the squat however, upon movement the athlete typically steps into a lunged position. Therefore, with the similarities in sport motion to that of the lunge, and equal if not greater activation of the lower extremity, the lunge is an ideal activity to train athletes.

KEY WORDS: sEMG, quadriceps, hamstring.

INTRODUCTION: The back squat is a common exercise for performance strength training and rehabilitation with focus on quadriceps and hamstring activity. Contrary to common clinical practice, variation in stance width during the squat does not affect the isolation of quadriceps musculature (McCaw & Melrose, 1999; Signorile et al, 1995). With the increased focus on the hamstring musculature for injury prevention, especially the anterior cruciate ligament, exercises such as the lunge are more commonplace. Thus, the purpose of this study was to examine the gluteal, quadriceps and hamstring muscle activation at three different squat depths and during the body weight lunge.

METHOD: Eight healthy, female intercollegiate athletes (mean age 20.8 + 3.9 y; mean height, 177.8 + 10.9 cm; mean mass, 67.3 + 9.9 kg) consented to participate in the study. The study was approved by the Institutional Review Board. Prior to testing, adhesive 3M Red-Dot bipolar surface electrodes were placed over the muscle bellies on the subject's dominant side according to method of Basmajian and Deluca (1985) with an interelectrode distance of 25 mm (Hintermeister et al.1998). The muscles targeted were the following: rectus femoris, vastus lateralis, vastus medalis obliques, medial hamstring (semimembrinosus and semitendinosus), biceps femoris, gluteus medius and maximus.
Manual muscle tests were performed through maximum isometric voluntary contractions (MVIC) based on the work of Kendall et al. (1993). Three manual muscle tests were performed for a total of five seconds for each muscle group. The first and last second of each MVIC trails were removed from the data in attempt to obtain steady state results for each of the muscle groups. Each subject then performed several warm-up squats to assure proper technique and proper depth prior to each trail recording. Each subject performed five weighted squats of 70% of their body weight to 90°, 60°, and 30° of knee flexion respectively. Each subject was allotted three minutes of rest between the different depths. During the trials subjects were instructed on proper posture through verbal cues. After the squats were completed the subject also performed five body weight lunges with body weight only. In addition to EMG data, video data were also collected from a 90˚ lateral view to assure appropriate technique as well as to event mark trials. All trials were event marked for concentric and eccentric phases.
A Myopac Jr 10 channel amplifier (RUN Technologies Scientific Systems, Laguna Hills, CA) transmitted the all EMG raw data at 60 Hz via a fiber optic cable to the receiver unit. The EMG unit has a common mode rejection ratio of 90 dB. The gain for the surface electrodes was set at 2000. EMG data were recorded, stored, and analyzed with the analog data acquisition package of Peak Motus Software (version 9.0; Peak Performance, Englewood,

CO). EMG enveloped data were assessed. Mean maximum EMG reference values were calculated for each muscle within the phase. Five trials of EMG data for each subject were analyzed to determine average peak amplitudes for all muscles during each concentric and eccentric phase of the exercise.

Data Analysis: Data from each muscle were normalized as a percent of the contribution of electrical muscle activity of the MVIC. The Levene's test was performed to determine homogeneity of the variables, all variables except rectus femoris violated the Levene's statistic. Therefore, nonparametric Kruskal-Wallis tests were used to observe if the exercises (lunge and the squat at 90°, 60°, and 30°) had a main effect on the muscles involved (rectus femoris, vastus lateralis, vastus medialis oblique, semitendinosus, biceps femoris, gluteus maximus, and gluteus medius). Where exercise affected the muscle activity, Mann-Whitney tests identified specific differences between each exercise and each muscle. The level of significance was set at $p<0.05$ and all tests were performed using SPSS 15.0 (Chicago, IL).

RESULTS: Table 1 presents the summed ranks for rectus femoris, vastus lateralis, vastus medialis oblique, semitendinosus, biceps femoris, gluteus maximus, and gluteus medius for the 90°, 60°, 30° squats, and the lunge. Figure 1 illustrates the rank differences between the three different squat depths and the lunge. Kruskal-Wallis tests revealed a significant main affect for exercise type on the rectus femoris (χ^2=15.706, p=0.001); vastus medialis oblique (χ^2=8.767, p=0.03); vastus lateralis (χ^2=15.169, p=0.002); semitendinosus (χ^2=8.775, p=0.03); biceps femoris (χ^2=14.258, p=0.003); and gluteus medius (χ^2=10.387, p=0.02). Exercise type did not have a main affect on gluteus maximus muscle activity (p=0.05).

Specifically as illustrated in Figure 1 post-hoc Mann Whitney tests revealed that the rectus femoris had higher activation during the 90° compared to the 60° (U=6.5, p=0.007) or 30° squat (U=2.0, p=0.002) and during the lunge (U=6.0, p=0.006) compared to the 30° squat. The vastus medialis obliques had higher activation during the 90° squat compared to the 30° squat (U=11.5, p=0.03) and during the lunge compared to the 30° squat (U=7.0, p=0.009). The vastus lateralis had higher activation during the 90° squat compared to the 60° squat (U=9.5, p=0.02), and the 30° squat (U=5.5, p=0.005) and during the lunge compared to the 60° squat (U=7.5, p=0.01), and compared to the 30° squat (U=4.0, p=0.003). The semitendinosus/semimembrinosus had higher activation during the 90° squat compared to the 30° squat (U=4.5, p=0.004) and during the lunge compared to the 30° squat (U=11.0, p=0.03). The biceps femoris had higher activation during the 90° squat compared to the 30° squat (U=8.5, p=0.01) and during the lunge compared to the 90° squat (U=9.5, p=0.02), 60° squat (U=11.5, p=0.03), and compared to the 30° squat (U=2.0, p=0.002). The gluteus medius had higher activation during the lunge compared to the 90° squat (U=6.0, p=0.006).

Table 1 Summed ranks for each muscle based on exercise type.

	RF	VMO	VL	SEMI	BF	MAX	MED
90° Squat	24.88	18.88	22.31	20.56	17.56	14.44	16.19
60° Squat	12.63	16.50	11.75	16.5	14.56	14.31	16.38
30° Squat	8.06	8.69	8.56	8.5	8.25	12.88	9.19
Lunge	20.44	21.94	23.38	20.44	25.63	24.38	24.25
Chi-Square	15.706	8.767	15.169	8.775	14.258	7.791	10.387
Significance	0.001	0.033	0.002	0.032	0.003	0.051	0.016

Legend: Rectus femoris (RF), vastus medialis oblique (VMO), vastus lateralis (VL), semitendinosus and semimembrinosus (SEMI), biceps femoris (BF), gluteus maximus (MAX), and gluteus medius (MED).

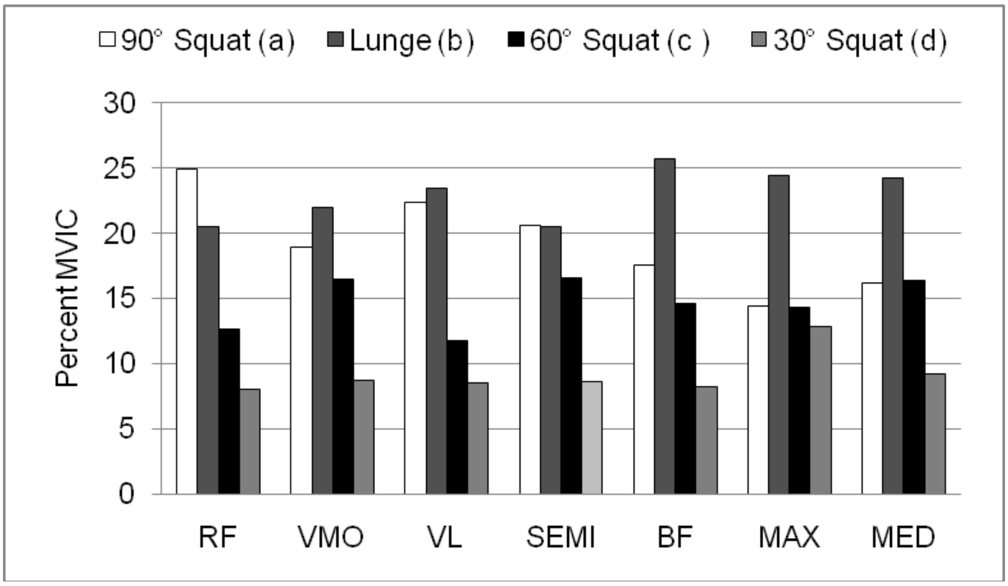

Figure 1. A comparison of the summed ranks of the percent muscle activation for the 90°, 60°, 30° squats and the lunge.
Legend: Rectus femoris (RF), vastus medialis oblique (VMO), vastus lateralis (VL), semitendinosus and semimembrinosus (SEMI), biceps femoris (BF), gluteus maximus (MAX), and gluteus medius (MED).

DISCUSSION: The results demonstrated that there was no greater muscle activation when performing any of the squat depths to that of the body weight lunge. It was revealed that the body weight lunge did indeed produce more activation in the majority of all muscles analyzed when compared to the three squat depths. Although two muscles, the rectus femoris and semitendinosus/semimembrinosus, displayed greater activation during the 90° squat when compared to the lunge, however this difference was not significant.
Thus, in attempt to enhance athletic performance, we want to focus on training athletes functionally for their sport not necessarily functional for the weight room. Functionality comes into question when one assesses how the athlete resumes their athletic position. If an athlete is in competition and is placed in a position where the knees are flexed to 90° there is a much greater chance that the athlete is either going to fall to the ground or walk out of the position. Majority of athletes move from a base position, which mimics the squat however upon moving the athlete naturally has to step forward, backward, or side to side. This step is crucial to transfer energy from potential to kinetic, therefore with the increased activation of the lower extremity muscles and sports function clinicians should train athletes from a lunge position.

CONCLUSION: By training the athletes in the body weight lunge, they can obtain the same results of that of squat to 90˚ training. The lunge allows the athlete to be in a more sport functional position. From the basic lunge position of the knees flexed to 90˚ we can begin to train explosive recovery moves, which would transfer over to competition. Ideally, athletes should be training their kinetic chain fluidly and dynamically; the more dynamic the activity the more fluid the athlete’s movement and posture will be in competition. As a coach, personal trainer or athletic trainer, we should begin to worry when movement gets ridged because of the susceptibility to injury.
As an athletic trainer conditioning for rehabilitation or a coach training for performance, the data reveals that athletes do not need any type of equipment to train optimally and functionally. Using the athlete’s own body weight and proper lunging instruction, they can maintain optimal activation of the primary muscles involved. Therefore, for those teams who do not have the weight room facility, the athletic trainer or coach can instruct the athletes on strength training and rehabilitation exercises on the actual playing surface, whether it be field or court.

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