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4-Week Neuromuscular Training Program on Peak External Power in the Back Squat in Division II Collegiate Athletes

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SENIOR THESIS APPROVAL

This Honors thesis entitled

4-week neuromuscular training program on peak external power in the back squat in division II collegiate athletes

written by

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the requirements for completion of
the Carl Goodson Honors Program
meets the criteria for acceptance
and has been approved by the undersigned readers.

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4-week neuromuscular training program on peak external power in the back squat in division II collegiate athletes

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Abstract

Neuromuscular training has been shown to have many benefits to athletes ranging from increases in performance to decrease in injury risk by decreasing knee valgus in some athletes. The purpose of this study is to determine if neuromuscular training can influence power in athletes. It is hypothesized that with the intervention program there will be a significant increase in power in the sample. A 4-week neuromuscular training program was implemented with resistance trained athletes (Age: 20.13±.99 yrs., n=14). This training involved balance and plyometric exercises. A pretest and posttest consisted of 2 sets of 6 repetitions of a back squat at 60-70% of 1RM. The back squats were performed on a force plate and with a linear position transducer to gather force and velocity respectively. The average power produced in a back squat in the post test had a significant increase from the average power in the pretest (pre: 2188.77 ± 606.26 W; post 2544.95 ± 607.33 W, $p = < .001$). All athletes measured power increased except one, with an average increase of 356.18 ± 312.68 W. A significant increase in power was observed after the neuromuscular training intervention.

Key words: Neuromuscular training, power, back squat, force, velocity

Introduction

Dobbs et al. (2021) defines neuromuscular training as "a range of training modes including resistance training, plyometrics, dynamic stability, core strength development, and speed and agility training to enhance movement skill competence, physical fitness, and to target movement limitations or deficits" (p. 2). Neuromuscular training is a common intervention used in the mitigation of risk for Anterior Cruciate Ligament (ACL) Injuries. Within the literature it is evident that neuromuscular training is effective in reducing the risk of ACL injury. However, it is not clear that neuromuscular training may influence other performance metrics such as power. This study aims to determine if neuromuscular training can induce improvements in athletes' power. It is expected that there will be an increase in power as a result of the training intervention. All intervention program activities were approved by a certified strength and conditioning specialist. The Ouachita Baptist University Institution Review Board approved this study (IRB #SMI080323).

Review of Related Literature

Power in sports involves various loads to optimize power output with the goal of increasing both force and velocity capabilities (Kirby et al., 2010). Power is a combination of force and velocity, meaning that higher velocity does not always mean a higher power and a higher force does not always mean a higher power. Training with loads close to 50% 1RM are suggested for training power (Kirby et al., 2010). For testing power, the same loads should be used to test power to avoid athlete fatigue and determine consistent performance (Hori et al., 2006). Power can be determined for weightlifting activities where the bar is close and stationary to the lifter's center of gravity using a force plate and a linear position transducer (Hori et al., 2006). For testing power, the same load has been suggested to be used for every test so professionals can monitor athletes' progress. It is important to note that in this study, power will be defined according to the definition provided by Noffal and Lynn (2012) for external power, where aggregate of the power produced by multiple joints is measured. The literature supports the method for determining power that was used in this study.

Neuromuscular training has been shown to be a way to bridge the gap between rehabilitation and increasing performance. Neuromuscular training has been shown to decrease Q-angle in athletes and thus led to a decrease in knee valgus, which has been shown to lower risk factors for injury (Fernandes et al., 2019). Athletes with greater Q-angles are thought to be more at risk for ACL injuries than those with less valgus forces acting on the knee. In a study done by Gould et al. (2016), they found that the athletes with a greater Q-angle contributed to a greater pelvic width and femoral length which has been found to play a significant role in ACL injuries, rather than just the Q-angle measurement (Gould et al., 2016). In a study by Myer et al. (2011) on female athletes, neuromuscular training provided a beneficial outcome by decreasing the ACL injury rates in the female athletes. However, in this same study, there was no exact correlation between ACL injury and Q-angle. The injury prevention program consisted of many different plyometric exercises and technique analysis, like other studies done with neuromuscular training. (Meyer et al., 2011). The findings on Q-angle and the effects of ACL injury have had conflicting results within the literature, but neuromuscular training has been shown to be beneficial to Q-angle measurements and decreasing the risk of ACL injury over time, suggesting Q-angle and ACL injury risk may be non-related variables. Mandelbaum et al. (2005) conducted a large-scale study with a sample of female soccer athletes who underwent a neuromuscular training warm up protocol utilizing plyometric drills which later provided a suggested decrease in risk of ACL injury (Mandelbaum et al., 2005). Additional studies have found neuromuscular training reduces the incidence of ACL injuries in female athletes and in response to a targeted neuromuscular training protocol (Hewett et al., 2006; 2017). Overall, it is apparent that neuromuscular training has an impact on reducing the risk of ACL injury.

Neuromuscular training has also shown to improve peak velocity in male athletes for the back squat. This would have a direct effect on the improvement of power since an improvement of velocity would contribute to an improvement of power if the same load was used (Dobbs et al., 2021). Another reason neuromuscular training programs are effective is because of the increase in conscious thinking of knee control when working on agility and the emphasis on their movements when undergoing stresses on the knee. This promotes musculoskeletal health while attaining a mastery in complex motor skills (Gholami et al., 2023). In another study by Myer et al. (2005), a neuromuscular training program that lasted six weeks showed to improve multiple performance metrics including biomechanical valgus and varus forces on the knee.

Overall, the literature provides insight to how neuromuscular training can both reduce injury as well as increase performance in athletes. The mechanisms of these findings involve improvements in biomechanics, often measured in decreased Q-angle or valgus force, and improvement in muscular control. This suggests an increase in power may be seen from the neuromuscular intervention since force production could increase due to the improvements in biomechanics and muscular control.

Methods

Experimental Design

A one-group pretest-posttest design experiment with a cohort of 15 volunteer colligate athletes were used in a neuromuscular training intervention program from a convenience sample.

All 15 subjects underwent a pretest the day before the start of the invention program that continued for a duration of 4 weeks. The posttest was conducted 2 days after the final intervention training session on the fourth week. Subjects had the option to pick 3 days out of the 5 hosted intervention training sessions per week to meet the requirements for compliance in this study. A minimum of 10 out of the 12 hosted sessions were required to be included in the data and meet the compliance standard. Three student athletes familiar with resistance training principles attended all sessions. There were not enough volunteers recruited for a control group.

Subjects

Fifteen collegiate athletes at a NCAA Division II institution were voluntarily recruited for this study. Inclusion criteria requirements included an orthopedic examination from the current season on file with Ouachita Baptist Athletic Training, being resistance trained for over 1 season of the respective NCAA Division II sport and have recently performed a back squat in the past 30 days. Participants were excluded if they had any previous lower extremity injury reported in the last 6 months. A mean age of 20.13±.99 years was reported with a range of 18-22 years. 14 of the subjects report swimming as their primary sport while 1 reported track and field as their primary sport. Within the 15 subjects, 3 female athletes and 12 male athletes were reported. One subject was excluded due to sustaining a lower extremity injury outside of the intervention protocol.

Squat Power Testing

Force Plates (Kinvent Deltas) and a linear position transducer (RepOne, New York, 2023) were used to collect both peak force and peak velocity respectively to respectively to calculate power based on the equation Power = force x velocity, a method based on previous literature used to calculate power in sport (Hori et al., 2006; Noffal and Lynn, 2012; Cormie et al., 2007). The pretest consisted of the athlete performing a self-led warm up to 60-70% of their 1 rep max (1RM). For this study, the 1RM for the subject was the most they had reported lifting in the last 30 days. They were also instructed not to exert beyond a reported rate of perceived exertion (RPE) above 14 on the Borg's RPE scale. 1RM testing was not performed prior to the pretest due to time constraints and the subjects being in season for their primary reported sports. After the warm-up was completed, the athlete practiced stepping on to the force plates with no weight within the confinements of a squat rack. After the subject felt comfortable stepping on to the plates, they performed 2 sets of 6 repetitions of a back squat with the weight they reported to be 60-70% of their 1RM. 60 seconds of rest was given between both sets for each subject. The fastest average peak velocity reported from the linear position transducer between the 2 sets was recorded for data collection along with the peak force given by the force plates. These two numbers were then multiplied to calculate power. The same procedure was conducted for the posttest. The same weight for the pretest was used for the posttest for each individual subject. All subjects were spotted by an individual while performing the whole test. All subjects were given additional rest if warranted. Both the pretest and posttest were conducted in the Sturgis Physical Education Center Weight Room.

Neuromuscular Training Protocol

The neuromuscular training program used in this study was a synthesis of exercises found in previously published studies on neuromuscular training (Fernades et al., 2019 & Myer et al., 2005). 5 training sessions were held each week for 4 weeks. Subjects had the option of attending and completing 3 training sessions a week at their own leisure cohesive with their schedule. The execution of exercise was done by independent effort and at the subject's own pace. The exercise protocol consisted of 3 sets of 10 repetitions of squatting on an unstable surface which consisted of 2 proprioception discs with a focus on a slow eccentric movement to a fast concentric movement of the quadriceps, 3 sets of 10 repetitions of lower extremity abduction at 45 degrees with a resistance band while standing, and 3 sets of 10 repetitions of lateral crossover leaps with a focus on the eccentric load of the quadriceps muscle group. For week 1, a set of 10 repetitions of Bulgarian splits squats with the front leg on a proprioception disk plate was performed for each leg. For weeks 2, 3 and 4, lateral step ups with a contralateral resistance were performed for 2 sets of 10 repetitions. All sets and reps were performed at the volunteer's own pace, but all sessions started with the squatting on unstable surface exercise. All sets were observed and recorded for safety and compliance. The intervention program was held in the Ouachita Department of Kinesiology Biomechanics and Exercise Science laboratory in the Sturgis Physical Education Center.

Figure 1. Squatting on an unstable surface using two proprioception disks

Figure 2. Lateral step ups with a contralateral resistance

Figure 2. Bulgarian split squats on an unstable surface

Figure 4. Lateral crossover leaps

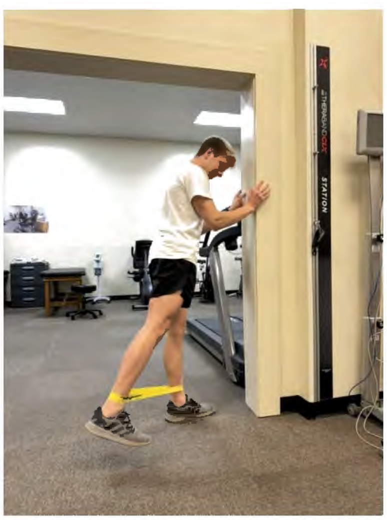

Figure 5. Lower extremity abduction at 45 degrees with a resistance band while standing

Data Analysis

Data was expressed as a mean and standard deviation. For comparison of pre and post intervention scores, a paired t-test was used. The *p*-value was set to $p < .05$ for data analysis. Statistical Package for Social Sciences (SPSS, IBM) was used for data analysis.

Results

A significant improvement in peak external power was seen between the pre and post intervention mean scores ($p < .001$) The mean of the pre intervention score was 2188.77 ± 606.26 W. The mean of the post intervention score was higher at 2544.95 ± 607.33 W. The mean increase between the pre and post intervention scores was 356.18 ± 312.68 W. All but one subject improved. That subject disclosed that they had had a pre-workout supplementation during the pre-intervention assessment and not the post intervention assessment.

Table 1. Pre and post test results

	Mean (W)	Significance
Pre-Test Power	2188.77±606.27	
Post-Test Power	2544.95±607.34	
Difference	356.18±312.68	p = <.001

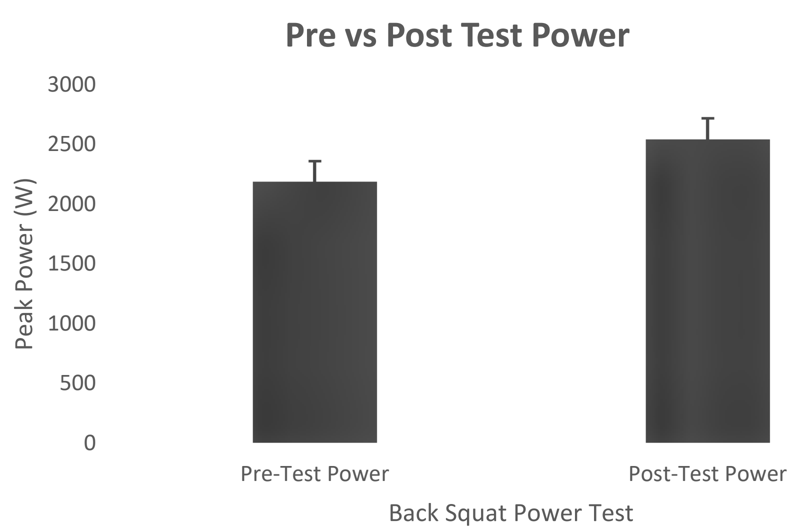

Figure 6. Pre vs Post test measures for power in the back squat. Measured post-test power was significantly greater (p=<.001)

Discussion

The absence of a control group in this study limits the significance of the findings. Many other variables could have played a role in the increase of the measured power of the athletes, such as motivation, external training outside of the intervention, and unreported supplementation. However, it can be noted that the neuromuscular training program likely had an influence on the performance in the post test. The results can suggest that the increase in power was in part due to the influence neuromuscular training has on power and neuromuscular control (Meyer et al., 2005). If more studies were provided with evidence of performance improvement caused by neuromuscular training, then programs could be implemented widely across athletic programs to both prevent injury and improve performance for highly motivated athletes.

It is important to note that the methodology of determining power in this study looked at what is defined as external joint or whole-body power (Noffal and Lynn, 2012). “Whole-body” refers to the culmination of multiple joint powers resulting in the elevation of the body. To increase the power generated by the muscles on multiple joints, a greater use of the stretch shortening cycle (SSC) is needed to attain a higher calculated power output (Noffal & Lynn, 2012). Plyometric exercises, which were utilized in this study, are known to increase force, power, and rate of force production compared to concentric exercises alone (Duchateau & Amiridis, 2023). The lateral crossover hop was utilized to work on the SSC and engage the gluteal muscle group. The intervention designed and derived from Fernandes and Meyer was designed to utilize the SSC and promote use of the gluteal muscle group to promote lateral stability. It has been shown that increased gluteal activation with a low load exercise has led to increased power output in countermovement jumps measured with a linear position transducer (Crow et al., 2010). In addition to gluteal activation, neuromuscular training warm-ups have been shown to increase muscular reactivation in a more ACL protective way (Zebis et al., 2016). All of this can combine to utilize more force production and create a greater rate of force production from the joints.

Future Direction

It is noted that neuromuscular training shows its greatest benefits with female athletes, making this a better population to implement this study on, especially in high risk for ACL injury sports such as soccer and basketball (Hewett et al., 2006). This study would also benefit from being repeated with a larger sample with a control group. Additional reliability for this study would likely be achieved with a longer intervention time as many adaptations for interventions are seen in those 6 weeks or greater. All future direction will be and has been taken into account, leading to a project which has been funded by the American College of Sports Medicine Central States Chapter with the CSACSM Undergraduate Research Grant for a study titled "A 6-week neuromuscular training intervention on peak external power in the back squat in female high school basketball and soccer athletes”. This research will be conducted in Fall 2024 with the Ouachita Baptist University Department of Kinesiology.

Conclusion

Neuromuscular training may have an impact on back squat power in collegiate athletes. Further research is needed to determine the effects of neuromuscular training on back squat power.

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