

Effects of a six-week speed, agility and quickness training program on EMG activation during jumping performance in female soccer players

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Abstract:

Female participation in soccer has grown markedly in recent years; however, this increase is not yet supported by training programs specifically aimed at enhancing performance in women athletes. To address this gap, the effects of a speed, agility, and quickness (SAQ) training protocol on muscle activation among female soccer players has been investigated. Twenty amateur female players were randomly assigned to either an experimental group (EG; n = 10), which underwent a 6-week SAQ training, or a control group (CG; n = 10), which maintained their regular routines. Electromyographic (EMG) activity of the rectus femoris, biceps femoris, and gastrocnemius was recorded during squat jumps (SJ) and drop jumps (DJ), both pre and post the intervention. The aim of the study was to determine whether SAQ-focused training could enhance neuromuscular activation—specifically, whether such training would increase EMG signals during SJ and DJ performance among female soccer players. Post-training ANOVA analyses revealed that the EG exhibited significantly increased activation of the rectus femoris during both SJ and DJ compared to baseline ($p \leq 0.05$). Additionally, gastrocnemius activation during the concentric phase of the DJ has significantly increased after the intervention in the EG ($p \leq 0.05$). No significant changes were detected in the biceps femoris of the EG ($p \geq 0.05$), nor were there any significant EMG alterations in the CG ($p \geq 0.05$). These findings suggest that a 6-week SAQ training program is effective in enhancing muscle activation—particularly in the rectus femoris and gastrocnemius—during explosive movement tasks. This neuromuscular improvement may translate into better on-field performance for female soccer players. The results support the design and implementation of gender-specific SAQ interventions to optimize training outcomes in women's soccer.

Key Words: Neuromuscular adaptation, lower limb muscle activation, explosive strength, female athletic performance, plyometric tests, pre-season training intervention

Introduction

Female participation in soccer has considerably increased in recent years (Krustrup et al., 2005). Previous research has demonstrated that female soccer players exhibit distinct anthropometric and morphological characteristics (Juric et al., 2007), lower aerobic capacity (Krustrup et al., 2005), and different responses to specific game situations (Bangsbo, 1994; Shepard, 1999) compared to their male counterparts. These differences suggest that both match play and training demands may be gender-specific.

A number of studies have investigated the effectiveness of various training programs on improving soccer-related physical performance (Dutta & Subramaniam, 2002; Sedano et al., 2011). For instance, a 12-week strength and power training program appears to have enhanced sprinting and jumping performance (Wong et al., 2010), while plyometric training produced positive adaptations in explosive muscular strength (Sedano et al., 2011; Sedano et al., 2009). Similarly, a 6-week isokinetic training program significantly improved kicking accuracy in soccer players (Dutta & Subramaniam, 2002). Despite these findings, the majority of previous studies has focused on male participants, with limited evidence addressing female soccer players.

The speed, agility, and quickness (SAQ) method has become a popular training approach and is frequently recommended as an alternative means to enhance reaction speed, change of direction, coordination, balance, and neuromuscular activity (Brown et al., 2005), particularly in team sports such as soccer (Jovanovic et al., 2011; Pearson, 2001). A typical SAQ session incorporates explosive movements, progressing from fundamental motor skills to position-specific drills (Yap & Brown, 2000). The rationale of SAQ training is to develop speed, agility, and quickness through soccer-specific exercises that address both shared and unique characteristics of these components.

It is believed that SAQ training enables soccer players to react more effectively to stimuli, improving acceleration, multidirectional movement efficiency, and the ability to decelerate or change direction rapidly in a smooth, fast, and repetitive manner (Polman et al., 2009). Several studies have reported performance benefits from SAQ training, including improvements in agility test performance (Milanovic et al., 2013), straight-line sprint speed (Milanovic et al., 2014), and flexibility of the lower back and hamstrings (Polman et al., 2004). Bloomfield et al. (2007) further emphasized the importance of SAQ training for the development of speed and quickness.

However, not all findings are consistent. For instance, Jovanovic et al. (2011) reported no improvements in agility performance during the in-season period among young male soccer players. However, some aspects of power performance were positively affected.

Overall, there is a plethora of published data suggesting that SAQ training can induce meaningful adaptations in several biomechanical and performance-related variables. Nevertheless, the majority of these studies have been conducted with male athletes. Research specifically addressing female soccer players is scarce, and training programs for women are often adaptations of models originally designed for men.

Therefore, the purpose of the present study is to investigate the effects of a SAQ training program on electromyographic (EMG) activity during jumping tasks in female soccer players. The main hypothesis was that participation in the SAQ training program would result in significantly greater muscle activation compared to pre-training values.

Material & methods

Participants

Twenty amateur female soccer players volunteered to participate in the study. Participants were randomly assigned to two groups. The experimental group (EG) consisted of 10 players (age: 20.1 ± 1.4 years; body mass: 57.6 ± 4.6 kg; height: 166.4 ± 6.7 cm; training experience: 5.6 ± 1.2 years). The control group (CG) also included 10 players (age: 21.1 ± 2.8 years; body mass: 65.7 ± 4.4 kg; height: 165.2 ± 3.1 cm; training experience: 6.1 ± 1.4 years).

Procedure/Test protocol/Skill test trial/Measure/Instruments

Training Program: In addition to their regular soccer practice, the EG completed a 6-week training program, three sessions per week, conducted at the same time of day during the pre-season period. A detailed outline of the training program is provided in Appendix 1.

- **Week 1:** General strength training of upper and lower limb muscles, six exercises, 3×10 repetitions at 40–60% of 1RM.
- **Week 2:** Speed and general strength development, including 5m, 10m, 20m, and 30m sprints, combined with four strength exercises (3 sets, progressive intensity).
- **Weeks 3–4:** Speed and maximum strength training, including repeated 10–30m sprints and four strength exercises (3 sets, progressive intensity).
- **Weeks 5–6:** Speed and explosive strength training, including 5–20m sprints and high-intensity plyometric exercises. Adequate rest intervals were provided between exercises and sets.

The CG continued with their regular soccer-specific training but did not participate in systematic strength or conditioning sessions during the experimental period.

Electromyography: Surface electromyographic (EMG) activity (Farina et al., 2014; Komsis et al., 2014) was recorded during the jumping tests using a KISTLER system interface module (Model 5606A, 16 A/D channels) at a sampling rate of 1000 Hz. Bipolar surface electrodes (metallic bars, 1 cm inter-electrode distance) were connected to a 16-channel analog amplifier (common mode rejection ratio: 100 dB at 50/60 Hz; bandwidth: 8–500 Hz; gain: 400).

Electrodes were placed longitudinally along the muscle fibers at the center of the muscle belly for the rectus femoris (RF), gastrocnemius (GAS), and biceps femoris (BF) of the preferred leg, following SENIAM guidelines (Hermens et al., 2000).

These muscles were selected due to their critical role in jumping performance (Bobbett & Van Ingen Schenau, 1988; Van Soest et al., 1993). Before electrode placement, the skin was shaved and cleaned with alcohol to minimize impedance.

EMG signals were processed using MYOS software (Kitsas, 2011), developed in MATLAB (version 6.1; The MathWorks Inc., Natick, MA, USA). The root mean square (RMS) value of the EMG signal was calculated, as it provides a reliable measure of muscle activation during dynamic voluntary tasks (De Louca, 1997).

Jump Tests

Participants performed squat jumps (SJ) and drop jumps from a 30 cm height (DJ30) on a Kistler piezoelectric forceplatform (Type 9281C, Kistler Instruments, Winterthur, Switzerland). The force platform was connected to Kistler amplifying units (Type 233A). Signals were sampled at 1000 Hz and analyzed simultaneously with EMG data.

Each participant performed three maximal SJ and DJ30 trials following a standardized warm-up. The best attempt in terms of jump height, both pre- and post-training, was selected for further analysis.

	WEEKS										
	1	2		3		4		5		6	
Training method	General strength	Speed	General strength	Speed	Maximum strength	Speed	Maximum strength	Speed	Exposive strength	Speed	Exposive strength
Number of exercises	6	4	4	2	4	2	4	3	3	3	1
Training exercises	1. Depth jump from a box 2. Abdominal exercise 3. Lunge 4. Static jump with 1kg dumbbell 5. Throwing a 3kg medicine ball 6. Side abdominal exercise	5m-10m-20m-30m	1. Barbell back squats 2. Barbell straight back stiff leg deadlift 3. Deadlift 4. Seated hip adduction	10m-20m	1. Leg extension 2. Leg curl 3. Calf raises 4. Seated hip adduction	20m-30m	1. Leg extension 2. Leg curl 3. Calf raises 4. Seated hip adduction	5m-10m-20m	1. Two (2) barbell back squats; jumps over four (4) hurdles (30cm); 10m sprint 2. Two (2) one leg squat (right & left); four (4) standing long jumps and 5m sprints; 3. Five metre (5m) sprint forward; 5m sprint backwards; 5m sprint forward and kick a ball to a goalpost	5m-10m-20m	1. Drop jumps from 30cm; jumps over four (4) hurdles (30cm); 5m sprint left; 5m sprint right; dribbling a ball through four (4) cones and kick a ball to a goalpost
Overall sets	3	2	3	2	3	2	3	2	8	2	2
Repetitions	10	8-6-5-4	12X30%-10X40%-8X50%	20 & 10	8 & 6 & 4	10 & 10	6 & 4 & 2	12 & 8 & 4	3	12 & 8 & 4	6
Intensity	40-60% of 1RM	50-60% of 1RM	30-50% of 1RM	90-100% of 1RM	High	Maximum	60% - 70% - 80%	Maximum	High	Maximum	High
Rest	90 sec between exercises and 3 minutes between sets	90 sec between exercises and 3 minutes between sets	90 sec between exercises and 3 minutes between sets	60 sec between exercises and 3 minutes between sets	120 sec between exercises and 5 minutes between sets	60 sec between exercises and 3 minutes between sets	120 sec between exercises and 5 minutes between sets	30 sec between exercises and 3 minutes between sets	120 sec between exercises and 3 minutes between sets	30 sec between exercises and 3 minutes between sets	120 sec between exercises and 3 minutes between sets

Appendix 1. 6 week training program

Statistical analysis

A two-way analysis of variance (ANOVA) with repeated measures on the second factor (2×2 design) was applied to evaluate the effects of the training program and to detect significant differences in the dependent variables across pre- and post-tests.

In addition, independent samples t-tests and paired samples t-tests were employed where appropriate to further examine within- and between-group differences. All statistical analyses were conducted using the SPSS software package (version 18.0; SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $p \leq 0.05$.

Results

Drop Jumps Electromyography

During the **eccentric phase** of the drop jump, a significant increase in rectus femoris activation was observed in the experimental group when comparing post- to pre-training values ($p \leq 0.05$;

Figure 1; Table 1). No significant differences were found in biceps femoris and gastrocnemius activation for either group ($p \geq 0.05$; Figure 2; Table 1).

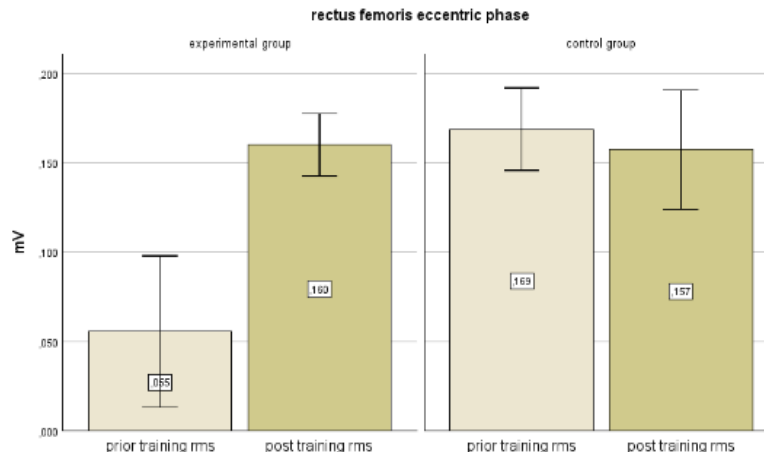


Figure 1. Rms on rectus femoris during eccentric phase

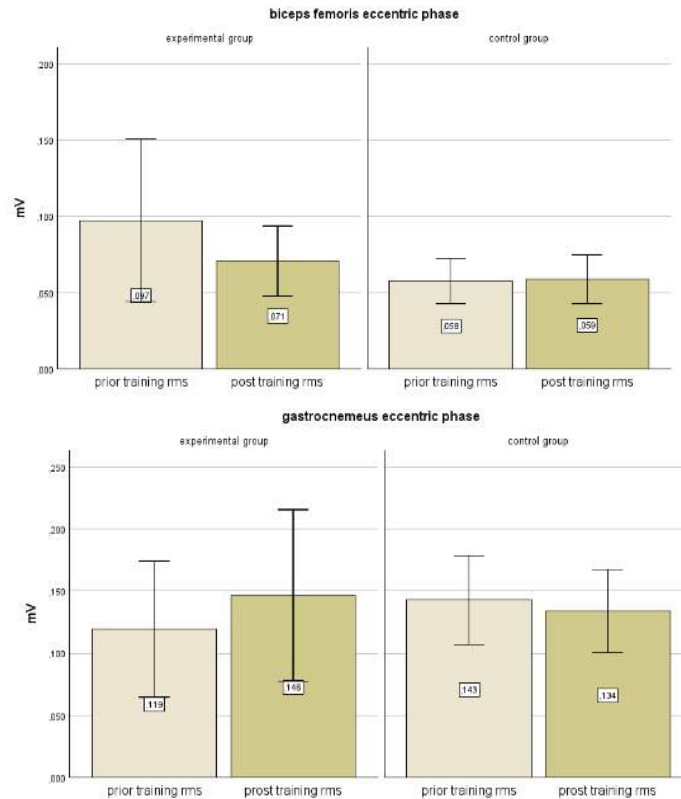
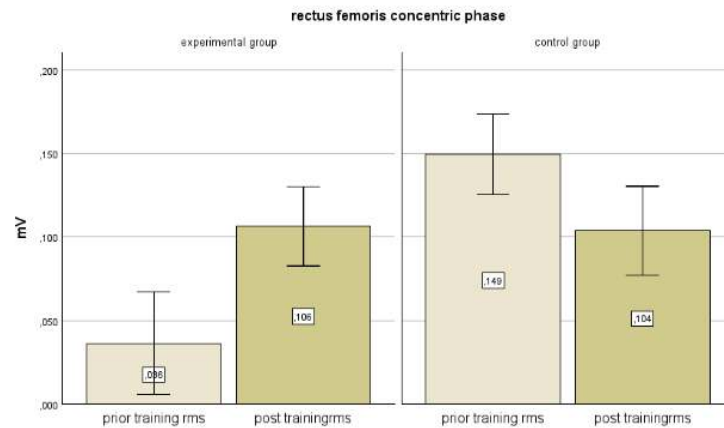


Figure 2 Rms on biceps femoris and gastrocnemius during eccentric phase

Table 1. Drop jump during the eccentric phase in experimental and control group

Drop jump Experimental group	pre	post	Drop jump Control Group	pre	post
Rectus femoris eccentric phase	.055±.06	.110±.02	Rectus femoris eccentric phase	.168±.03	.157±.05
Biceps femoris eccentric phase	.097±.07	.071±.03	Biceps femoris eccentric phase	.058±.02	.059±.02
Gastrocnemius eccentric phase	.119±.08	.146±.10	Gastrocnemius eccentric phase	.143±.05	.134±.04

During the **concentric phase** of the drop jump, significant increases were recorded for rectus femoris and gastrocnemius activation in the experimental group ($p \leq 0.05$; Figures 3 and 4, Table 2). In contrast, no significant changes were observed for biceps femoris activation ($p \geq 0.05$; Figure 5; Table 2).



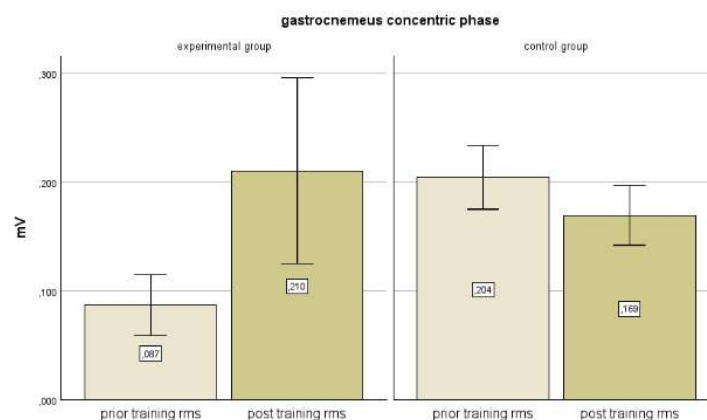


Figure 3, 4. Rms rectus femoris and gastrocnemius during concentric phase

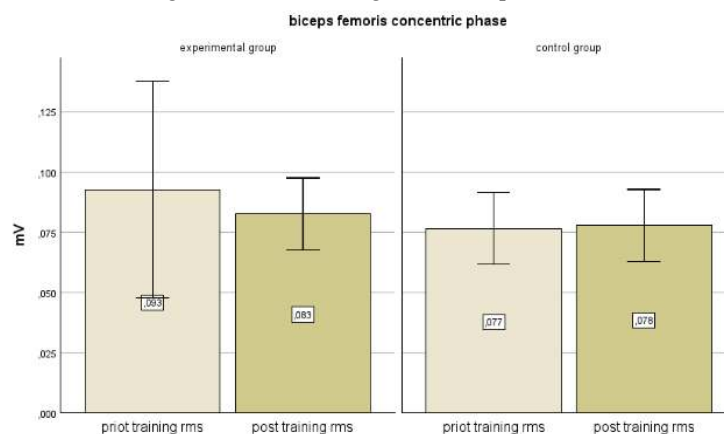


Figure 5. Rms biceps femoris during concentric phase

Table 2. Drop jump during the concentric phase in experimental and control group

Drop jump Experimental group	pre	post	Drop jump Control Group	pre	post
Rectus femoris concentric phase	.036±.04	.106±.03	Rectus femoris concentric phase	.149±.03	.104±.04
Gastrocnemius concentric phase	.087±.04	.210±.12	Gastrocnemius concentric phase	.204±.04	.169±.04
Biceps femoris concentric phase	.093±.06	.083±.02	Biceps femoris concentric phase	.077±.02	.078±.02

Squat Jumps Electromyography

During the **pre-activation phase**, a significant increase in rectus femoris activation was observed in the experimental group following the training intervention ($p \leq 0.05$; Figure 6; Table 3). No significant changes were detected in gastrocnemius and biceps femoris activation in either group ($p \geq 0.05$; Figures 7–8; Table 3).



Figure 6. RMS rectus femoris during pre activation phase

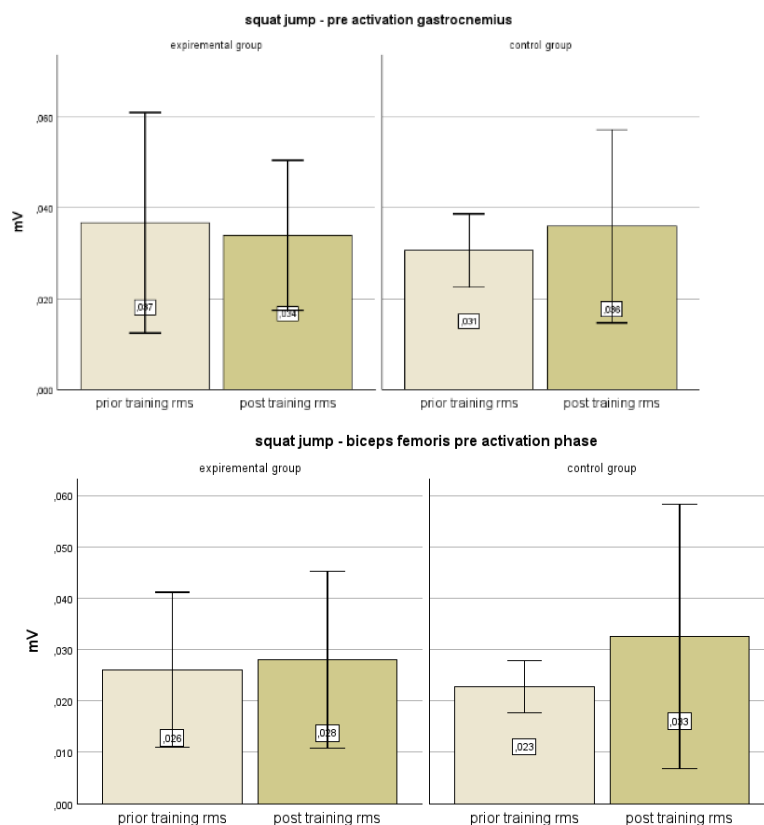


Figure 7, 8. RMS gastrocnemius and biceps femoris during pre activation phase

Table 3. Squat jump during the pre activation phase in experimental and control group

Squat jump Experimental group	pre	post	Squat jump Control Group	pre	post
Rectus femoris pre activation phase	.029±.06	.061±.02	Rectus femoris pre activation phase	.062±.03	.077±.05
Biceps femoris pre activation phase	.026±.07	.028±.03	Biceps femoris pre activation phase	.023±.02	.033±.02
Gastrocnemius pre activation phase	.037±.08	.034±.10	Gastrocnemius pre activation phase	.031±.05	.086±.04

During the **activation phase**, rectus femoris activation was significantly higher in the experimental group after the training intervention ($p \leq 0.05$; Figure 9; Table 4). No significant changes were observed for gastrocnemius and biceps femoris in either group ($p \geq 0.05$; Figures 10–11; Table 4).

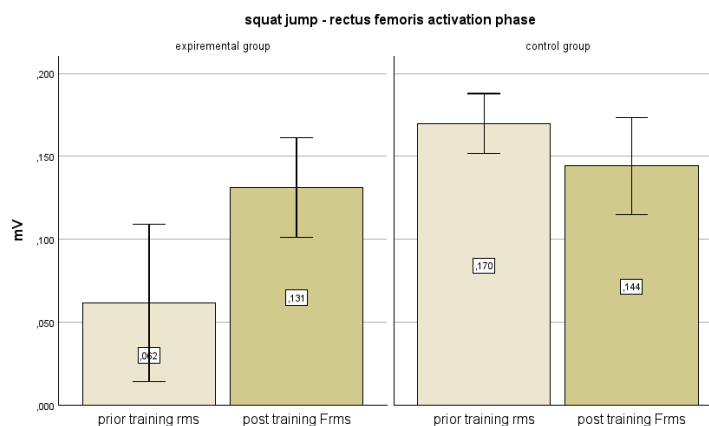


Figure 9. RMS rectus femoris during the activation phase

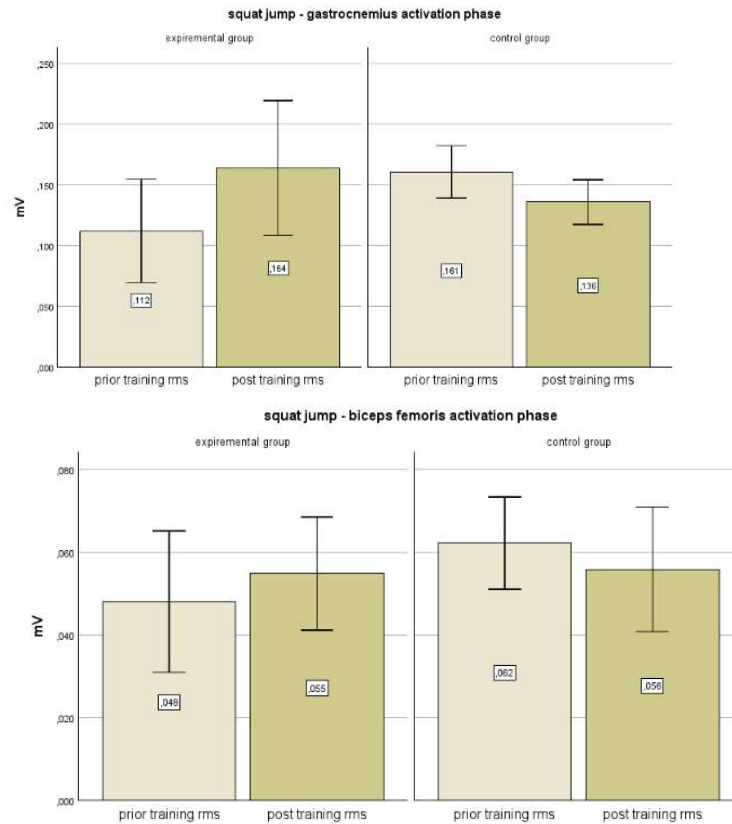


Figure 10, 11. RMS gastrocnemius and biceps femoris during activation phase

Table 4. Squat jump during the activation phase in experimental and control group

Squat jump Experimental group	pre	post	Squat jump Control Group	pre	post
Rectus femoris activation phase	.062±.06	.131±.02	Rectus femoris activation phase	.170±.03	.144±.05
Biceps femoris activation phase	.048±.07	.055±.03	Biceps femoris activation phase	.062±.02	.056±.02
Gastrocnemius activation phase	.112±.08	.164±.10	Gastrocnemius activation phase	.161±.05	.136±.04

Discussion

The purpose of this study is to examine the effects of a 6-week SAQ training program on electromyographic responses of female soccer players during drop jumps and squat jumps. The main findings support the initial hypothesis: the intervention resulted in significantly increased rectus femoris and gastrocnemius activation in selected phases of the jumps, whereas no consistent improvements were observed for the biceps femoris.

These results are in line with previous research, highlighting the role of SAQ training in enhancing explosive lower limb performance and neuromuscular efficiency (Bloomfield et al., 2007; Milanović et al., 2013, 2014; Polman et al., 2009). Jovanovic et al. (2011) reported mixed effects regarding agility but also emphasized positive adaptations in muscle performance. More recent findings (Formenti et al., 2021; Trecroci et al., 2016) suggest that combining closed and open motor tasks (sprints, COD, reactive movements) maximizes training effects on coordination and reactivity.

Previous investigations have incorporated speed, agility, and quickness (SAQ) training into football-specific drills and conditioning programs, examining its impact on players' physical performance (Bloomfield et al., 2007; Jovanovic et al., 2011; Milanović et al., 2013; Milanović et al., 2014; Polman et al., 2009; Sporiš et al., 2011; Trecroci et al., 2016). In the study conducted by Jovanovic et al. (2011) young football players engaged in an eight-week SAQ intervention during the competitive season. The findings demonstrated that the experimental group exhibited significant improvements in acceleration and short-distance sprint performance compared with the control group, which did not receive the intervention.

Milanović et al. (2014) reported that a 12-week intervention, combining SAQ and flexibility training, resulted in significant improvement in sprint performance, particularly over short distances of 5 and 10 m, when compared with players who followed only regular training routines. In addition, Formenti et al. (2021) emphasized that the effectiveness of SAQ training is maximized when it integrates both closed drills (e.g., sprinting and change-of-direction tasks) and open drills (e.g., balance and reactive movements). This approach, which blends football-specific and non-sport-specific stimuli, was shown to be especially beneficial for youth

athletes, as it accounts for their perceptual and cognitive responses. Similarly, Azmi et al. (2018) observed that an eight-week SAQ program elicited marked improvements in sprinting ability, agility, reaction time, and lower-body power among football players.

Moreover, evidence suggests that implementing a structured training intervention of at least 5–6 weeks is essential in order to achieve meaningful physiological and neuromuscular adaptations in highly trained football players during both the pre-season and competitive phases (Polman et al., 2009; Silva et al., 2015).

The training program implemented in the present study was found to increase rectus femoris EMG activation during both drop and squat jumps, as well as gastrocnemius EMG activation during the concentric phase of drop jumps. Comparable findings have been reported in previous research (Krustrup et al., 2005; Pedersen et al., 2009), indicating that tasks involving acceleration, deceleration and rapid changes of direction, can substantially influence quadriceps activation. Consequently, the increased rectus femoris activation observed in female soccer players in the current study was anticipated. Furthermore, neural adaptations induced by combined training modalities have been identified as key contributors to performance gains, particularly when implemented during an initial 6–8 week phase of strength training (Sale, 1988).

The purpose of SAQ training is to enhance athletes' capacity for explosive, multidirectional movements through neuromuscular reprogramming (Lennemann et al., 2013; Younget al., 2002). Collectively, these findings indicate that the aforementioned program constitutes an effective stimulus for enhancing muscle activation, which may, in turn, contribute to improved performance in female soccer players.

Conclusions

Research has demonstrated that Speed, Agility, and Quickness (SAQ) training effectively enhances crucial athletic performance components, including sprint speed, change-of-direction ability, neuromuscular activation, and explosive power. These neuromuscular adaptations are beneficial for improving sport-specific skills and overall athletic performance, particularly in team sports such as soccer. The results highlight that short-term (5–6 weeks) targeted training interventions can induce significant neural and physiological adaptations even in trained athletes, provided that they are applied during pre-season or in-season periods. This is consistent with previous research emphasizing the importance of acceleration–deceleration tasks and rapid directional changes in enhancing quadriceps and gastrocnemius activation.

From a practical perspective, these findings suggest that coaches and strength & conditioning practitioners should consider incorporating SAQ-based drills (including multidirectional sprints, change of direction exercises, and reactive movements) into female soccer players' training routines. Such methods can optimize neuromuscular function, support performance in high-intensity match situations, and potentially reduce the risk of injury through improved muscle activation patterns.

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