International Journal of EXERCISE SCIENCE

Original Research

In-Season Hip Thrust vs. Back Squat Training in Female High School Soccer Players

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ABSTRACT

International Journal of Exercise Science 13(4): 49-61, 2020. The barbell back squat provides a highly effective training stimulus to improve lower body strength, speed, and power, which are considered key components of athletic performance in many sports. The barbell hip thrust exercise utilizes similar musculature, and is popular among practitioners, but has received far less scientific examination. The purpose of this study was to evaluate the effects of an in-season resistance training program with hip thrusts or back squats on physical performance in adolescent female soccer players. Fourteen players completed identical whole-body resistance training twice per week for 6 weeks, except one group used the barbell hip thrust (HT) (n = 6) and the other the back squat (SQ) (n = 8). Improvements were observed for both groups in hip thrust 3RM (HT = 34.0%, SQ = 23.8%), back squat 3RM (HT = 34.6%, SQ = 31.0%), vertical jump (HT = 5.4%, SQ = 4.9%), broad jump (HT = 10.5%, SQ = 8.1%), ball kicking distance (HT = 13.2%, SQ = 8.1%), and pro-agility (HT = -1.5%, SQ = -1.5%; faster), but not 36.6-m dash (HT = 2.9%, SQ = 1.9%; slower) with no significant between-group differences. These data indicate that both the hip thrust and the squat provide an effective stimulus to improve these sport-specific performance measures. Practitioners should consider these findings in combination with other factors (equipment availability, ability to coach the movement, training goals, injuries, etc.) when selecting exercises.

KEY WORDS: Youth, resistance training, strength

INTRODUCTION

Resistance training is a popular and well-supported method of mitigating injury risk and improving athletic performance (15-19, 22-24, 30, 34). The barbell back squat provides an effective training stimulus to improve lower body strength, speed, and power, and is thus frequently prescribed by practitioners and sport scientists (4, 6, 18, 21, 31, 33, 34). The ability of this exercise to target the lower body musculature (1, 9) makes it particularly useful for soccer athletes (6, 17, 18, 28). The barbell hip thrust is another popular posterior chain exercise (3, 8-11, 13-15) that engages similar musculature (1, 9), and is often purported as a viable alternative to the back squat (18, 21, 34). This is noteworthy as some scientists suggest soccer players would benefit from comprehensive training protocols involving exercises that improve horizontal force production and mimic the demands of sprinting and kicking (20).

The transferability of the hip thrust to athletic performance remains inconclusive (3, 11, 13-15, 18, 21, 34). Loaded hip thrusts acutely improve 5-20 m sprint speed in handball (13) and soccer players (14), and are correlated with acceleration in elite sprinters (21). A chronic carry-over effect for sprint speed has been reported in some papers (11, 18, 34) but not others (3, 19, 34). Vertical and horizontal jumping ability also appears responsive to heavy hip thrust training in some 6-14 week training studies (11, 15, 18, 34), but not others (19). Contreras and colleagues directly compared the squat and hip thrust in adolescent athletes and identified several important differences (11). The hip thrust was 'potentially more beneficial' than the squat for short sprint (0-20 m) speed, while the squat was superior for vertical, but not horizontal, jumping (11). A similarly designed recent study supported this conclusion for sprint speed, but not vertical jump (18). Several factors could explain these discrepancies, including athlete sport, age, sex, and resistance training history.

These gaps in the literature limit the ability to develop and implement evidence-based strength and conditioning programs. Additional research is warranted to determine the efficacy of hip thrust training for athletic development. Therefore, the purpose of the study was to examine the effects of a 6-week resistance training program with hip thrusts or back squats on measures of performance (strength, jumping, speed, and ball kicking distance) in adolescent female soccer players.

METHODS

Participants

Eighteen healthy female competitive high school soccer athletes (Table 1) with no resistance training experience enrolled in the study and were randomly assigned to either the hip thrust (HT) or back squat (SQ) group (3 freshman, 7 varsity, 8 junior varsity; all were split between training groups). All members of the schools' soccer teams were given the opportunity to participate (i.e., no other inclusion or exclusion criteria). One subject was removed due to non-adherence (missed >3 training sessions) and three others were dropped due to sports injuries unrelated to the study. Full data sets were collected on the remaining 14 participants (age = 15.3 ± 0.8 y; height = 161.4 ± 7.0 cm; weight = 59.9 ± 14.9 kg) from HT (n = 6) and SQ (n = 8). Informed assent from all subjects' and consent from parents/legal guardians was obtained prior to any data collection. The California State University, Fullerton Institutional Review Board approved the protocol and all procedures, and the study abided by the rules of the Declaration of Helsinki. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (25).

Table 1. Descriptive Data

Group	Age (years)	Height (cm)	Weight (kg)
Hip Thrust (n = 6)	15.7 ± 0.8	162.6 ± 5.8	56.3 ± 6.4
Squat (n = 8)	15.3 ± 0.7	159.1 ± 7.2	56.7 ± 6.7

Protocol
Following a 2-week familiarization phase (detailed below), baseline performance measures were assessed on two consecutive days. Similar to previous research (2, 7, 16), a standardized 10 min dynamic warm-up (15 meters per movement of high knees, quadriceps stretch, hamstring dips, lateral lunge, figure-four stretch, lunge with twist, inchworms, carioca, and lateral shuffles) was completed prior to all testing and training sessions. Participants were instructed to refrain from exercise (including soccer practice) for 24 hours prior to testing. Testing day 1 included the 36.6-m dash, vertical jump, soccer ball kicking distance, and barbell (Power Systems, Knoxville, TN) hip thrust three repetition maximum (3RM). Testing day 2 included the pro-agility shuttle, broad jump, and barbell back squat 3RM. The average of 3 attempts was reported for all speed and jumping tests, while the average of 5 trials was utilized for the kicking test. Rest intervals between attempts were prescribed as: strength (2-5 min), jumping (1 min), speed (3-5 min), and kicking (1 min) tests. The rest interval between testing batteries (e.g., between the 36.6-m dash and vertical jump, etc.) was 15 min for the strength tests and at least 5 min for all other assessments. All testing and subsequent training sessions were supervised by the same research team members, who were National Strength and Conditioning Association Certified Strength and Conditioning Specialists.

Anthropometry: Height and body mass were measured with a measuring tape and digital scale.

Hip Thrust Strength: The procedures were similar to previous research (11, 15, 34). Briefly, subjects performed 3 warm-up sets (3-5 reps at 70%, 80, and 90% of estimated 3RM), followed by 2-3 attempts at a 3RM (5 minutes of rest between each set). The hip thrust was performed with the shoulders and feet elevated for all hip thrust testing and training. A barbell with bumper plates rested atop the subject's hip crease with the mid back rested on a stable bench and the feet slightly wider than shoulder width elevated on a separate bench (Figure 1). Subjects were instructed to extend their hips by pushing through the heels until fully extended with similar technique and safety measures as described previously (11, 15, 34).

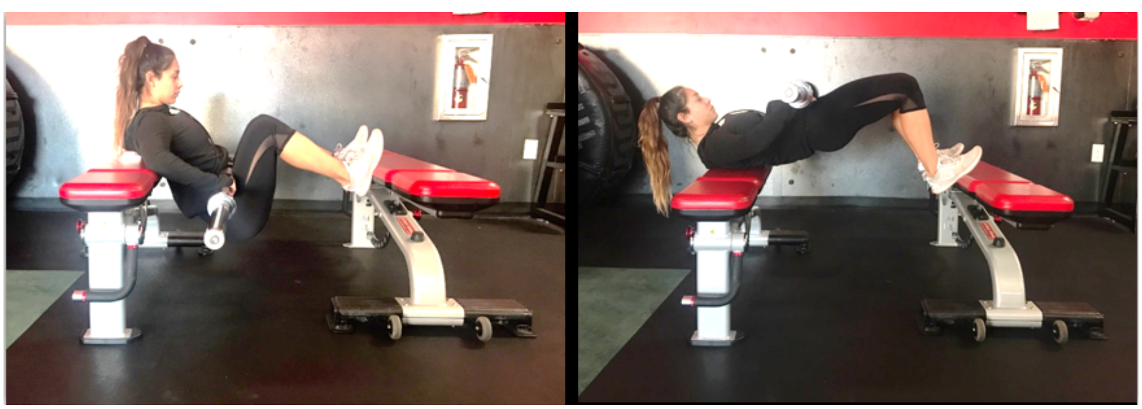

Figure 1. Feet Elevated Hip Thrust Exercise Starting and Finish Position**.**

Squat Strength: Subjects performed 3 warm-up sets, (3-5 reps at 70%, 80, and 90% of estimated 3RM), followed by 2-3 attempts at a 3RM (5 minutes of rest between each set). Subjects were required to reach parallel for the repetition to be considered successful as described in detail previously (6, 7, 11, 26, 31).

36.6-m dash: Timing gates (Brower Timing System, Draper, Utah, USA) were placed at 0-m and 36.6-m (40 yards). The test was performed on the grass soccer field and participants wore cleats. Subjects were instructed to set up with one foot directly behind the first timing gate.

Pro-agility shuttle: Timing gates (Brower Timing System, Daper, Utah, USA) were placed in a straight line 10 yards apart. The test was performed on the grass soccer field and participants wore cleats. Participants were instructed to straddle the starting line with one hand on the ground and to touch the white lines during both changes of direction (34).

Vertical Jump: Vertical jump height was assessed with a Vertec apparatus (Sports Imports, Columbus, Ohio, USA). Participants were instructed to start standing with both feet on the ground and use a countermovement arm swing to initiate the jump. Jump height was calculated as the difference between standing reach distance and countermovement jump height.

Broad Jump: Broad jump distance was assessed with a tape measure (Lufkin Reel Rewind Tape, 100’) and calculated as the difference between the starting and landing position of the rearward heel.

Kicking Distance: Maximal soccer ball (Nike Pitch Soccer Ball, size 5) kicking distance was measured from start position at the end line to initial contact with the ground utilizing the protocol described in (29). Participants performed a warm-up of 10 passes at 9.1-m, 18.2-m, and 27.4-m (29). Spotters were placed at 4.6-m increments to the 47.5-m line (mid-field). A 1-step approach was allowed prior to each kick, and the participants kicked with their preferred foot for all attempts (the same foot was used for all post-training kicking tests).

The first 2 weeks (4 training sessions) of the study served as a familiarization phase to allow participants to develop technical proficiency in the hip thrust and back squat. Participants were instructed how to properly perform the exercises until they consistently demonstrated appropriate technique for each movement. The protocol consisted of 3 sets of 10 repetitions of each exercise at ~50-70% of their estimated 3RM. This scheme was replicated based on a previous study by Contreras and colleagues (19).

Baseline performance testing occurred 48-96 hours after completing this familiarization period. The subsequent training program consisted of resistance training twice per week for 6 weeks. Training occurred on non-consecutive days and was typically separated by 48-72 hours. The athletes were instructed to refrain from any additional exercise (except typical soccer practice). Initial loading was set as 30% of 3RM and increased by ~10% each week. The training included ‘strength’ and ‘explosive’ hip thrusts or back squats followed by upper body and core exercises (Table 2). The players were reminded to perform the eccentric portion of every exercise under control with proper technique. However, during the 'strength' repetitions athletes were encouraged to focus on movement control with a tempo of 2-3 seconds eccentric, 0-1 isometric, and 2-3 seconds concentric. During the 'explosive' repetitions, athletes were encouraged to execute the concentric portion as fast and forcefully as possible (tempo: 1-2 sec eccentric, 0 isometric, as fast as possible concentric). Strength exercises were performed for 3 sets of 8 repetitions (3 x 8) during weeks 1-2, 3 x 6 during weeks 3-4, and 3 x 4 during weeks 5-6. Explosive exercises were performed for 4 x 6 during weeks 1-2, 5 x 4 during weeks 3-4, and 6 x 3 during weeks 5-6.

Table 2. The following program was performed twice per week for 6 weeks in adolescent female soccer players. Weight was progressively overloaded by ~10% per week based on athlete proficiency.

Day 1	Sets x Reps	Day 2	Sets x Reps
'Strength' Hip Thrust or Squat	3 x 4-8	'Explosive' Hip Thrust or Squat	4-6 x 3-6
'Explosive' Hip Thrust or Squat	4-6 x 3-6	'Strength' Hip Thrust or Squat	3 x 4-8
Bench Press	2 x 8	Overhead Press	2 x 8
Unilateral Row	2 x 8	Lat Pull Down	2 x 8
:30 Plank Hold	2 x 30s	:30 Plank Hold	2 x 30s

Statistical Analysis

Data were analyzed using ANCOVA on change scores with group as the predictor variable and pre-test value as a covariate to adjust for baseline values. Residuals from each model were extracted and tested for normality. Residuals were considered non-normal if the null hypothesis of the Shapiro-Wilk test was rejected at the $\alpha = 0.05$ level, leading to subsequent evaluation of the skewness and kurtosis of the distribution. Analyses were performed using SAS software 9.4 (SAS Institute, Cary, NC) and significance was established a priori at an alpha level of $p < 0.05$.

RESULTS

There were no statistically significant differences between HT and SQ for any measure ($p > 0.1$). ANCOVA results are presented as post-test least square mean (LSM) ± standard error (SE) in Table 3. Individual pre-post data are represented in Figures 2-5.

Table 3. Results of a 6 week strength training program in female high school soccer players. The primary columns (HT LSM and SQ LSM) display the post-test least square mean (LSM) ± standard error (SE).

	HT LSM ± SE	Change	% Change	SQ LSM ± SE	Change	% Change
3RM HT (kg)	90.59 ± 3.63	22.96	33.96%	83.65 ± 2.87	16.02	23.68%
3RM Squat (kg)	56.38 ± 1.99	13.92	32.88%	55.56 ± 1.61	13.13	30.94%
Vertical Jump (cm)	37.56 ± 2.34	1.13	3.12%	37.39 ± 2.02	0.96	2.64%
Broad Jump (cm)	204.1 ± 5.31	19.72	10.69%	199.66 ± 4.62	15.28	8.29%
36.6-m Dash (sec)	6.07 ± 0.078	0.158	2.67%	6.03 ± 0.055	0.105	1.77%
Pro-Agility (sec)	5.25 ± 0.078	-0.094	-1.75%	5.27 ± 0.069	-0.082	-1.54%
Kicking (m)	23.59 ± 1.49	2.59	12.37%	22.55 ± 1.35	1.550	7.38%

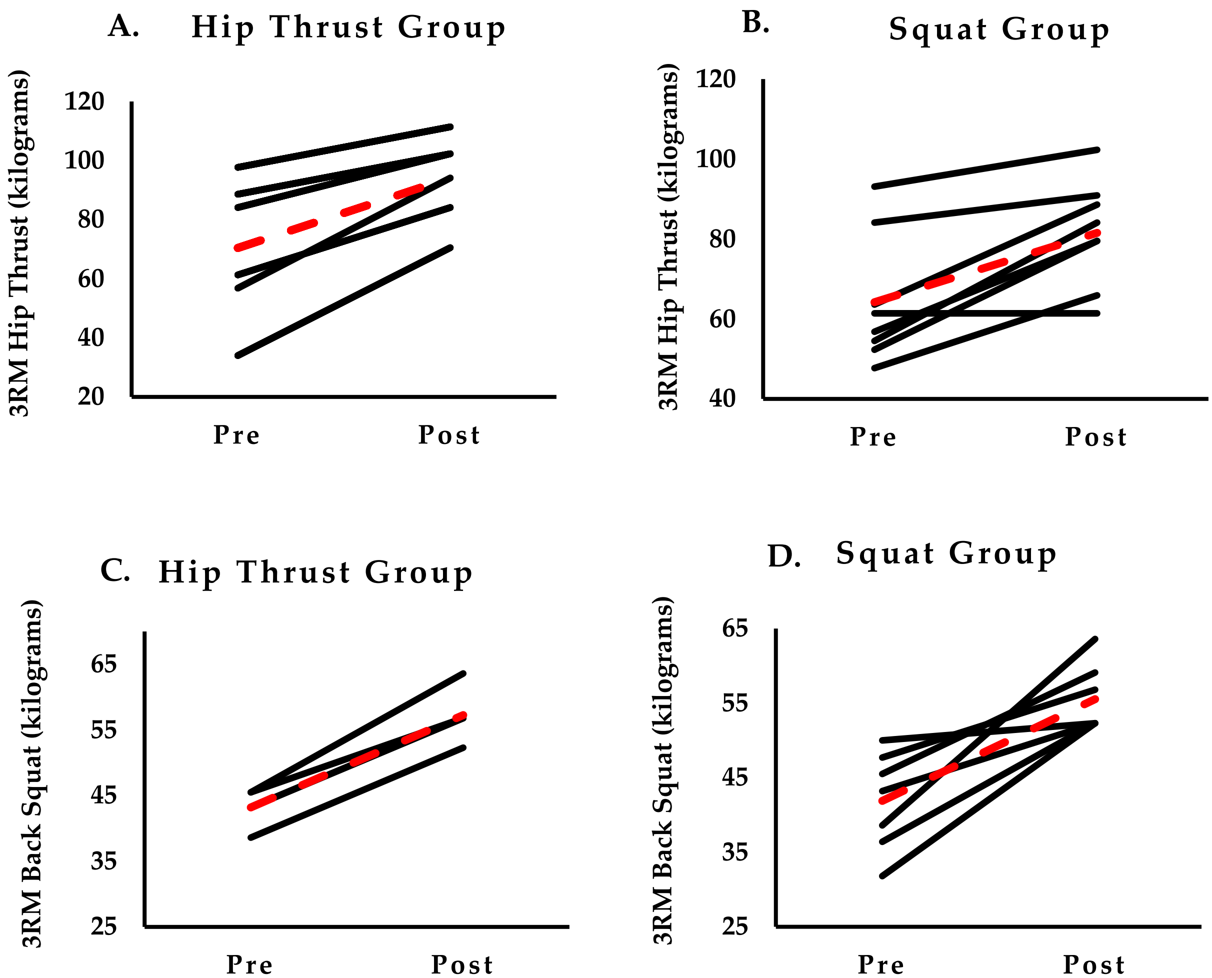

Figure 2. Individual athlete changes in strength following 6 weeks of in-season resistance exercise in female high school soccer players. Black lines represent pre- to post-intervention changes. Red dotted line represents the group average. Not all individuals are visible as several values overlapped with others (i.e., two individuals with similar values).

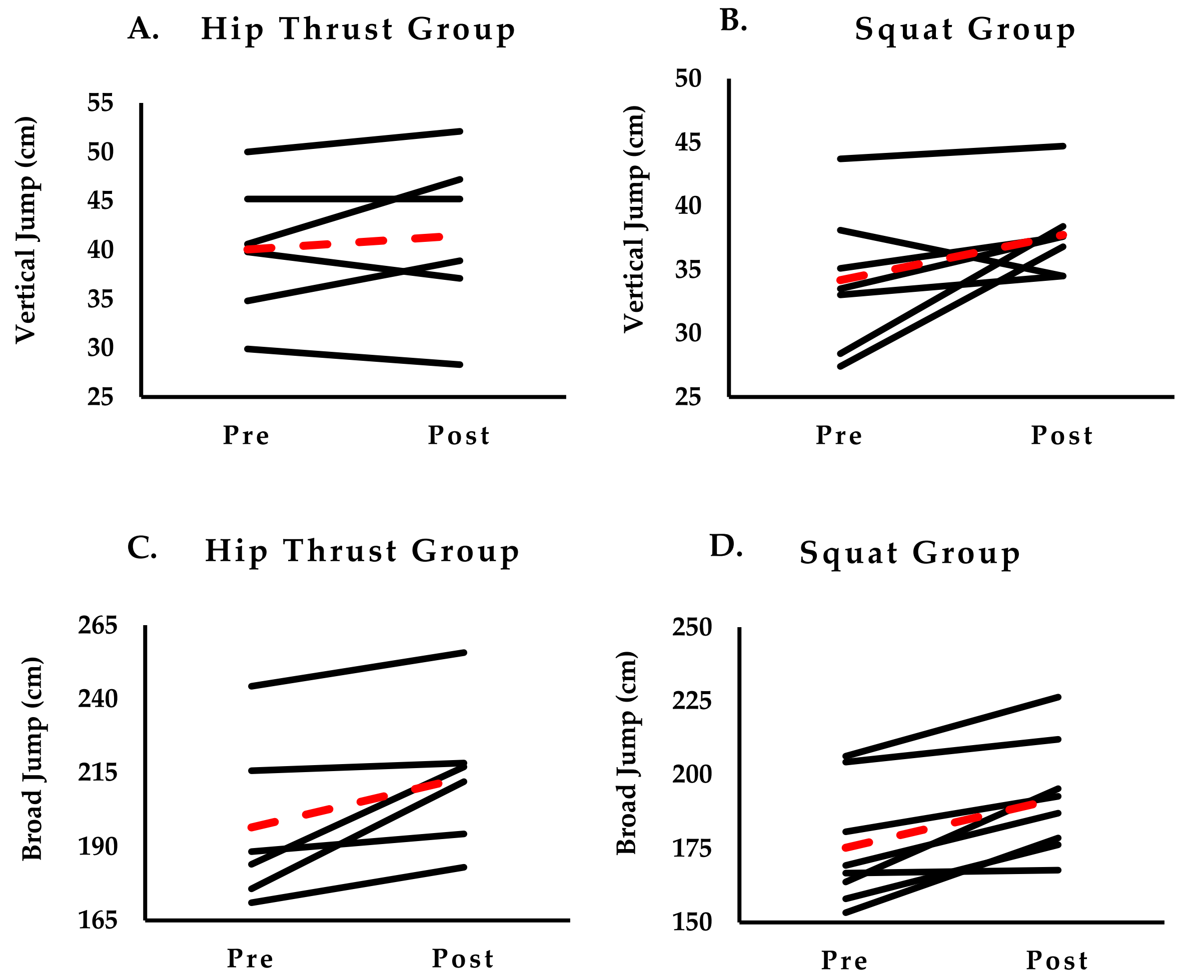

Figure 3. Individual athlete changes in jumping following 6 weeks of in-season resistance exercise in female high school soccer players. Black lines represent pre- to post-intervention changes. Red dotted line represents the group average. Not all individuals are visible as several values overlapped with others (i.e., two individuals with similar values).

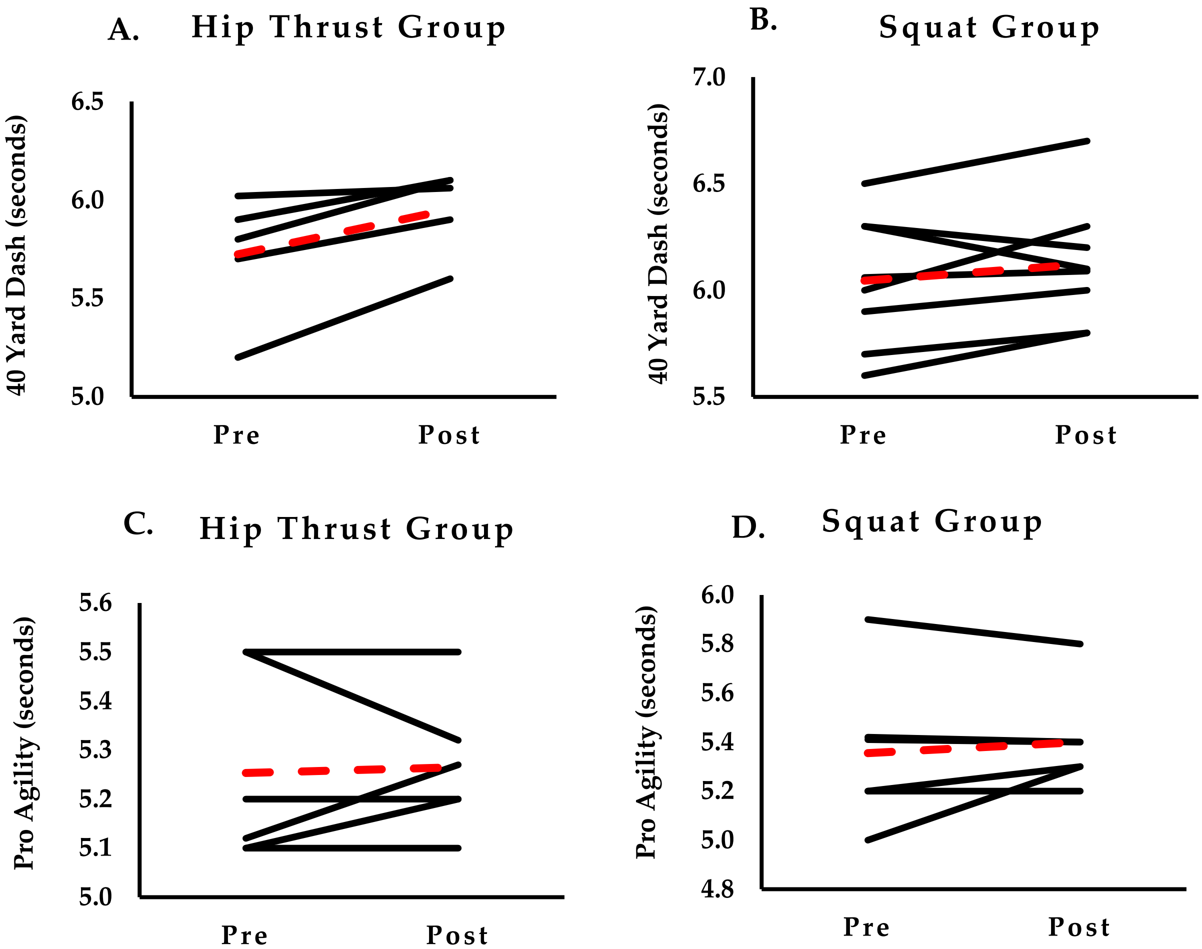

Figure 4A-D. Individual athlete changes in speed following 6 weeks of in-season resistance exercise in female high school soccer players. Black lines represent pre- to post-intervention changes. Red dotted line represents the group average. Not all individuals are visible as several values overlapped with others (i.e., two individuals with similar values).

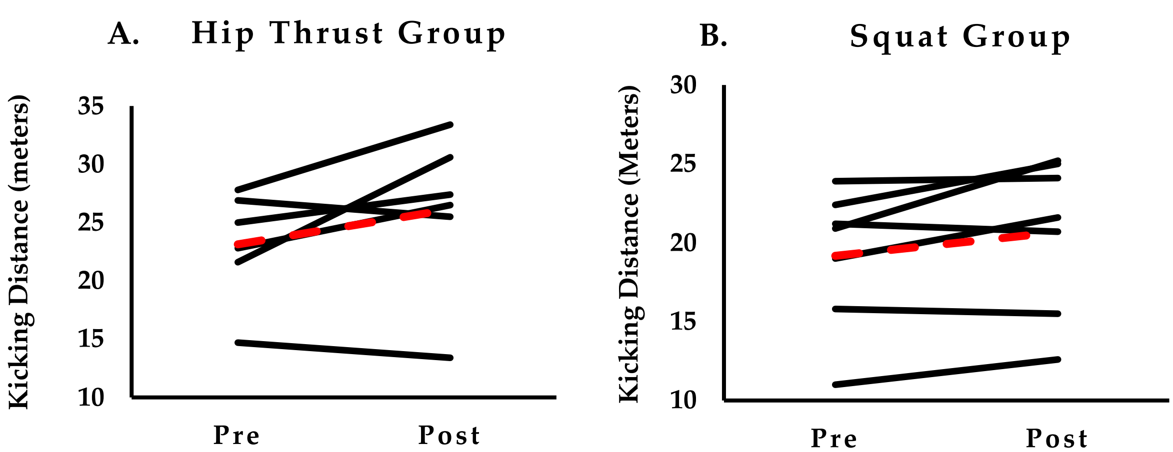

Figure 5. Individual athlete changes in kicking distance following 6 weeks of in-season resistance exercise in female high school soccer players. Black lines represent pre- to post-intervention changes. Red dotted line represents the group average. Red dotted line represents the group average.

DISCUSSION

We investigated the potential differences in physical performance adaptations following hip thrust or back squat training in adolescent female soccer players. To our knowledge, this is the first study to implement 1) the feet elevated hip thrust variation and 2) to execute it explosively. Globally, our data indicate both the loaded barbell hip thrust and back squat are viable options under the current circumstances (e.g., previously untrained adolescent female soccer players, in-season) for developing strength, jumping, and ball kicking distance, but not sprint speed. We caution against interpreting these results to mean both exercises yielded identical outcomes, or that the hip thrust was clearly superior to the back squat. The authors provided the raw scores, percent changes, and individual athlete data for each variable to enable readers to make value judgements based on their personal context. For example, a difference of 2.4% improvement in broad jump between HT and SQ (10.5 vs 8.1%) might be meaningful in a particular situation and negligible in another. Another key consideration is that athletes of different sports, ages, resistance training backgrounds, and phases of the year will likely respond differently than the current results suggest.

The strength increases reported here were influenced greatly by the athletes' lack of resistance training experience. The novel stimuli facilitated improvements analogous to previous research, with several notable differences. As expected, squat strength gains were higher (~30-35%) than both Contreras et al. (11) (~7-10%) and Styles (31) (~20%), who utilized previously trained or higher-caliber adult athletes, respectively. Male junior soccer players with no strength training experience reported similar, but slightly lower (~25%) increases in squat strength following 8 weeks of training (6). One study in strength trained female college athletes did report equivalent increases in hip thrust strength (~33%), but did not specify the subject's previous experience in either the squat or hip thrust (15). In another experiment, 14-17 year old rugby players and rowers with at least one year of strength training and squatting (but not hip thrust) experience performed 6 weeks of either hip thrusts or front squats (11). The HT group mimicked the current study; ~42% increase in hip thrust (vs. our 34%) and 23% increase in squat (vs. our 24%) 3RM strength, highlighting a clear specificity and responsiveness to a novel task (i.e., the hip thrust) effect. On the other hand, both studies reported far less specificity for the squat exercises with only ~3-4% differences in strength gains between the squat vs. HT groups. These results collectively support the ability of a barbell squat and a novel hip thrust exercise to enhance both squat and hip thrust strength in adolescent athletes, regardless of previous resistance training experience. However, maximizing hip thrust strength appears to require training the specific movement.

The ~5-10% increases in jumping ability shown here were equal or greater than most comparable research (6, 11, 15, 19, 20). Training the squat alone in previously non-strength trained junior soccer players yielded improvements (~10%) in vertical jump height (6). Yet, the specific contribution each exercise delivers to jumping aptitude is controversial, stemming from debate over the existence and/or relevance of 'horizontal' and 'vertical' force vectors (8, 9, 11, 15, 20). Contreras, Cronin, & Schoenfeld first postulated the potential unique benefits of training each vector in 2011 (8). The theory gained further support after finding that front squat training yielded slightly greater improvements in vertical jumping ability than hip thrusts (11). Interestingly, neither exercise enhanced horizontal jumping. While these findings are notable, the breadth of the literature remains equivocal and difficult to interpret. Some report increases in both vertical and horizontal jumping (~6%) with only hip thrust training in a mix of young athletes (15, 18), yet 8 weeks of hip thrust training failed to benefit vertical and horizontal jumping in collegiate male baseball players (19). Another study in young female soccer players concluded both back squats and hip thrusts likely increased vertical jump height to a similar extent (18). Our data differ from all of these previous studies in that not only did horizontal jumping improve in both our groups (HT = ~10% and SQ = ~8%), it actually exceeded vertical jumping (which increased by ~5% in both groups). These conflicting findings are possibly driven by methodological variations, so more research is warranted. Perhaps the most important distinction between our work and others was our 1) use of the modified foot position (Figure 1) and 2) specific training of both power and strength. Future research should explore the veracity of this speculation and its potential relevance to practical outcomes.

Loaded hip thrusts can acutely improve 5-20 m sprint speed in handball (13) and soccer players (14), and are correlated with acceleration in elite sprinters (21). Furthermore, squat strength, sprint speed, and jumping height are highly correlated in elite soccer players (23, 31, 33). Thus, it is intriguing that the training program greatly improved strength and jumping ability, but failed to increase speed (36.6-m sprint or pro-agility shuttle). Short sprint speed (5-15 m) was improved in professional soccer players following both vertical and vertical + horizontal training (20) and Contreras and co-authors concluded the hip thrust was 'potentially more beneficial' than the front squat for 10 and 20-m sprint speed (11). Conversely, three other 7-8 week hip thrust training studies in athletes failed to yield improvements in short (0-40 m) sprint speed (3, 18, 19). The inadequate carry-over to speed in our athletes was not group-specific, indicating shortcomings of the program rather than either exercise per se. These data collectively indicate that athletes likely require more than strength training alone to optimally develop linear or change-of-direction speed (30).

Both training groups also demonstrated considerable improvements in maximal soccer ball kicking distance (~8-13%), though our study design did not account for the likely contributions sport practice made to this enhanced performance. The ~5% larger increase in HT (relative to SQ) is notable, but should be interpreted with appropriate restraint. Although one study reported ~13% and ~27% increases in ball kicking distance after 7 and 14 weeks (respectively) of plyometrics training in soccer players, there are very few comparable studies with sport-specific testing parameters. In the absence of such additional data, practitioners should consider the viability of both training strategies.

Possible limitations of the current study include intervention length (6 weeks), sample size, the novelty and complexity of the exercises, and the unpredictable amount of running performed during sport practice and games (which could interfere with performance improvements (28)). However, these issues were consistent across conditions and are a reality of research with athletes, especially in-season. Several of these limitations could be addressed by repeating this study during different phases of the macrocycle (e.g., off-season, pre-season, etc.). Perhaps the most relevant consideration was the lack of resistance training experience in our athletes. This distinction is important as highly sport-trained does not necessarily mean highly strength-trained. Thus, it is possible that a heightened response to general strength training detracted from our ability to compare potential differences in effectiveness of the two exercises.

The results indicate that both the loaded barbell hip thrust and back squat are viable options for improving physical performance, even when implemented during competitive sport seasons. However, additional exercises may be required to develop (or at least maintain) speed. Both exercises were well-tolerated with no incidents of injury. Exercise prescription is subject to numerous considerations, most of which are outside the scope of this study (e.g., equipment availability, coaching ability, desired adaptations, long-term athletic development, injuries, athlete skill, etc.). Thus, these data should not be interpreted as evidence that one exercise is globally superior to the other. Practitioners are encouraged to contextualize these findings, along with those of other relevant studies, in combination with their experience when determining which exercises to incorporate into an athlete's training program.

ACKNOWLEDGEMENTS

This research received no external funding. The first author served as the assistant soccer coach to the subjects in this study. Bret Contreras assisted in the design of the training protocol, but was not involved in data analysis or interpretation. The authors would also like to thank Angel Castaneda for his help in data collection.

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