

Original Research

The Effects of Concurrent Training on Female Soccer Players

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ABSTRACT

Background

Due to the high metabolic and physical demands in soccer, an optimal strength and conditioning program is essential. The benefits of resistance training and high-intensity interval training in young athletes has been well documented; however, the effect of a concurrent strength and metabolic conditioning program on female soccer players has yet to be investigated.

Purpose

This study examined the effects of an 8-week concurrent strength and metabolic conditioning program on body composition, flexibility, speed, agility, anaerobic capacity, strength, and power in female soccer players.

Methods

Body composition and performance testing measures were recorded in female soccer players ($n=14$, age= 16 ± 1.0 yrs) before and after an 8-week sports performance camp that combined high-intensity interval training methods and periodized resistance training. Performance testing included 3-site skinfolds, sit and reach, pro agility test, 40-yd sprint, 300-yd shuttle run, and vertical jump. Strength testing included a 5-repetition maximum back squat, shoulder press, and bench press, and a 3-repetition maximum power clean. Comparisons were made using a paired samples t-test, and Pearson's correlations between variables were calculated.

Results

Significant improvements were made in vertical jump ($p<0.05$), pro agility test ($p<0.05$), 40 yd sprint ($p<0.05$), squat ($p<0.05$), shoulder press ($p<0.05$), bench press ($p<0.05$), and power clean ($p<0.05$). There were significant correlations between power, agility and speed performance, and between power and strength.

Conclusion

A preseason concurrent strength and metabolic conditioning program can improve soccer players' explosive strength and performance. Training protocols that use low volume and high loads (3 sets of 5-RM) to improve neural adaptations and avoid muscular hypertrophy should be studied in future research.

Keywords

Concurrent training; Performance; Female soccer players.

Abbreviations

BMI: Body Mass Index; NSCA: National Strength and Conditioning Association; SD: Standard Deviation; HIIT: High-Intensity Interval Training; ACSM: American College of Sports Medicine.

INTRODUCTION

Soccer, a popular youth sport around the world, involves immense athleticism and physical fitness. Soccer demands high-levels of aerobic capacity, which can average 70-80% of maximal oxygen uptake.^{1,2} Performance also depends on the athlete's ability to execute and quickly recover from multiple bouts of high-intensity exercise near anaerobic threshold, as well as the power, and strength involved in kicking, jumping, and tackling.^{1,2}

Due to the high metabolic and physical demands of soccer, an optimal strength and conditioning program for female soccer players is essential. Training methods for soccer typically include long bouts of aerobic endurance activities, as high-levels of aerobic capacity are fundamental to optimizing performance.^{1,3} However, there are multiple fitness components that need to be addressed as part of the training program and coaches are seeking alternative strength and conditioning methods, such as concurrent training, to enhance strength, power, and anaerobic capacity. The purpose of concurrent training is to reap the benefits of both increased force development and improved aerobic adaptations, but contradicting research exists regarding the effectiveness of this training method.³ Some studies suggest that concurrent strength and aerobic training elicits conflicting metabolic adaptations^{4,5} while others report beneficial increases in power and performance.³

The independent benefits of single-mode resistance training programs and high-intensity conditioning methods in young athletes have been well documented. Resistance training programs, when properly designed and supervised, have been shown to safely and effectively increase muscular strength and power in young athletes.⁶⁻⁸ High-intensity training has been shown to improve aerobic capacity and sprint performance in young soccer players without negatively affecting strength-related power output.² However, there is limited research examining the effect of concurrent resistance training and conditioning methods on sports performance, specifically in female soccer players. The purpose of this study was to examine the effects of an 8-week concurrent training program on body composition, flexibility, speed, agility, anaerobic capacity, strength, and power in female soccer players.

METHODS

Participants

Fourteen female high school soccer players (mean±SD; age 16±1.0 years; height 64±2.7 inches; weight 129±14.1 lbs) volunteered to participate in this study. The University of West Florida Institutional Review Board (IRB) approved this research prior to beginning data collection. All participants and parents were informed

of the potential risks and benefits and provided written informed consent and parental consent prior to participation. During the first week of the study, participants performed the baseline testing protocol, followed by an 8-week training program. The final week consisted of the post-testing protocol (Table 1).

Procedures

Testing was conducted at the same time of day and on the same high school soccer field for both pre- and post-testing sessions. Anthropometric data such as age, height, weight, body mass index (BMI), and 3-site skinfold assessment were recorded first. Performance testing consisted of the sit and reach test for flexibility, the pro-agility test for agility, the vertical jump test for power, 40-yd dash for speed, and the 300-yd shuttle run for anaerobic capacity.

Skinfold Assessment

The athletes' height and weight were taken at the start of the testing sessions using a stadiometer (Detecto, Webb City, MO, USA), followed by skinfold measurements using Lange Skinfold Calipers (Beta Technology, Santa Cruz, CA, USA). The same researcher performed all pre- and post-skinfold assessments to ensure validity. All measurements were made on the right side of the body, with the subjects in the standing position. A 3-site method for females was used (triceps, suprailiac, and thigh) following standard ACSM skinfold testing procedures.⁹

Performance Testing Procedures

Following anthropometric measurements, the athletes performed a 10-minute general warmup consisting of dynamic movements and submaximal running intervals. The athletes were given a 5-10 minute rest period between each performance test, and were encouraged to drink water as needed during the testing sessions. The detailed testing procedures for each test are described in Appendix A.

Concurrent Training Program

Following the pre-testing protocol, the athletes participated in an 8-week concurrent resistance training and conditioning program for three non-consecutive days each week. The concurrent program was based on a CrossFit® model, designed specifically for youth athletes, and implemented by the researcher. Training sessions were held for 1 hour, 3 times per week, and were completed in a small group setting. A typical workout consisted of a dynamic warm-up, 3 sets of 3-5 repetitions of core lifts with accessory work, a brief high-intensity conditioning workout, and a cool-down period of stretching and mobility exercises. A sample of the volume and training loads during a 2-week period of the resistance

Week 1	Week 2	Week 2-9	Week 10
Performance Testing	Maximal Strength Testing	Concurrent Training Program	Day 1: Performance Testing Days 2 & 3: Maximal Strength Testing

training program is shown in Table 2, and a sample of the conditioning workouts is shown in Table 3.

Training loads were progressed weekly, based on individual abilities. In general, athletes were encouraged to progress by 2.5 to 5 lbs weekly for each lift. Lifts that were performed more than once per week, such as the back squat, were kept at the same load for both training sessions in that week. If the athletes were unable to complete the lift with proper technique at the chosen weight, the load was decreased by 2.5-5 lbs, or until the lift could be properly performed for the given training volume. Training volume remained the same across the 8-week period, and all lifts were performed for 3 sets of 5 repetitions, except for the power clean which was performed for 5 sets of 3 repetitions. The training schedule cycled over a two-week period, during which back squats and shoulder presses were performed on day 1, power cleans and pull-ups were performed on day 2, and back squats and bench press were performed on day 3. During the following week, back squats and shoulder presses were performed on day 1, deadlifts and pull-ups were performed on day 2, and back squats and bench press were performed on day 3. The third week of the cycle resumed with power cleans on day 1, and so on.

Conditioning workouts varied over the course of the 8-week program, with a strong focus on sprinting and change of direction. Examples of training methods included; short sprints between 10-100 meters, interval and circuit training (combined resistance exercises and medium distance running between 200-400 meters), high-intensity Tabata protocols, traditional CrossFit® benchmark workouts, and numerous footwork drills. Intensity was monitored by the athletes' rate of perceived exertion and the addition of resistance, repetitions, sets or overall volume of each pro-

gressive workout.

Statistical Analysis

A paired samples *t*-test was used to determine differences between pre- and post-testing scores. Pearson's correlations were calculated to determine if there existed any positive or negative association between the variables. The data were analyzed using SPSS (22.0) software and the level of significance was set at $p \leq 0.05$.

RESULTS

Anthropometrics

Age, height, weight, and 3-site skinfold measurements, BMI, body fat percentage, and lean body mass were measured and calculated for each athlete. Table 4 shows the mean body composition of the athletes before and after 8 weeks of concurrent training.

There was a statistically significant increase in body fat percentage from pre ($M=20.9\%$, $SD=4.3\%$) to post ($M=21.7\%$, $SD=3.7\%$) conditions; $t(13)=-2.5$, $p=0.025$. The mean increase in body fat percentage was 0.8% with a 95% confidence interval ranging from -1.5 to -0.1. The eta squared statistic (0.3) indicated a large effect size.

Performance Testing

There were a statistically significant increase in vertical jump height from pre ($M=17.9$ in, $SD=3.2$ in) to post ($M=19.2$ in, $SD=2.3$ in) conditions; $t(9)=-2.9$, $p=0.015$. The mean increase in vertical jump height was 1.6 in with a 95% confidence interval ranging from -2.9

Table 2. Sample Periodized Concurrent Training Program

	Monday	Wednesday	Friday
Week 1 (70%)	Back Squat 3x5 Shoulder Press 3x5	Power Clean 5x3 Pullups 3xmax reps	Back Squat 3x5 Bench Press 3x5
Week 2 (75%)	Back Squat 3x5 Shoulder Press 3x5	Deadlift 3x5 Pullups 3xmax reps	Back Squat 3x5 Bench Press 3x5

Table 3. Sample Conditioning Training Program

	Monday	Wednesday	Friday
Week 1	For time: 25-m suicide sprint 20 Ground to Overhead, 25# 25-m suicide sprint 15 Ground to Overhead, 25# 25-m suicide sprint 10 Ground to Overhead, 25# 25-m suicide sprint 5 Ground to Overhead, 25#	"Rowing Annie": 500 m row 50 situps 400 m row 40 situps 300 m row 30 situps 200 m row 20 situps 100 m row 10 situps	Tabata: Kettlebell swings Kettlebell push press Kettlebell SDHP Goblet Squat Burpees
Week 2	Footwork Drills: Tabata: Line hops forward Line hops backwards Line hops R Line hops L Patterns	Partner EMOM 10': 200 m Row 3 Power Cleans 75%	"Running Cindy" 20 min: 400 m run 5 pullups 10 pushups 15 air squats

Table 4. Athlete Body Composition Before and After 8 Weeks of Training

	Pre (n=14)	Post (n=14)
Age (year)	16.1±1.0	--
Body mass (lbs)	129.1±14.2	130.7±13.2
Height (in)	64.1±2.7	64.1±2.7
Body Mass index (kg m ⁻²)	22.1±1.9	22.3±1.9
Body Fat Percentage	20.9±4.3	21.7±3.7*
Lean Body Mass (lbs)	101.8±9.6	102.1±9.9

Values are mean±SD.
*Significant difference between pretests and posttests at $p \leq 0.05$.

to -0.4. The eta squared statistic (0.4) indicated a large effect size.

A statistically significant increase in the pro agility test from pre (M=5.36 s, SD=0.3 s) to post (M=5.01 s, SD=0.3 s) conditions; $t(9)=4.8, p=0.001$ was observed. The mean increase in pro agility scores was 0.4 s, with a 95% confidence interval ranging from 0.2 to 0.5. The eta squared statistic (0.6) indicated a large effect size.

There was a statistically significant increase in 40-yd sprint performance from pre (M=5.9 s, SD=0.3 s) to post (M=5.5 s, SD=0.3 s) conditions; $t(9)=6.4, p=0.000$. The mean increase in 40-yd scores was 0.5 s, with a 95% confidence interval ranging from 0.3 to 0.6. The eta-squared statistic (0.8) indicated a large effect size.

Strength Testing

There was a statistically significant increase in 5-RM back squat from pre (M=90 lbs, SD=11.6 lbs) to post (M=150 lbs, SD=27.6 lbs) conditions; $t(13)=-8.5, p=0.000$. The mean increase in 5-RM back squat was 60 lbs, with a 95% confidence interval ranging from -75.2 to -44.8. The eta squared statistic (0.8) indicated a large effect size. There was also a statistically significant increase in 5-RM shoulder press from pre (M=46.1 lbs, SD=11.6 lbs) to post (M=77.5 lbs, SD=15.5 lbs) conditions; $t(13)=-7.8, p=0.000$. The mean increase in 5-RM shoulder press was 31.4 lbs, with a 95% confidence interval ranging from -40.2 to -22.7. The eta-squared statistic (0.8) indicated a large effect size.

There was a statistically significant increase in 5-RM bench press from pre (M=63.2 lbs, SD=13.5 lbs) to post (M=80.7 lbs, SD=13.8) conditions; $t(13)=-5.6, p=0.000$. The mean increase in 5-RM bench press was 17.5 lbs, with a 95% confidence interval ranging from -4.3 to -10.7. The eta squared statistic (0.7) indicated a large effect size. There was a statistically significant increase in 3-RM power clean from pre (M=68.9 lbs, SD=12.1 lbs) to post (M=89.6 lbs, SD=14.6 lbs) conditions; $t(13)=-7.8, p=0.000$. The mean increase in 3-RM power clean was 20.7 lbs, with a 95% ranging from -26 to -15.4. The eta squared statistic (0.8) indicated a large effect size.

Correlations

The relationship between all variables was investigated using a

Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. There was a moderate, negative correlation between vertical jump and pro agility test time, $r=-.641, n=12, p<0.05$, with high scores in the vertical jump associated with faster pro agility times. There was also a strong, negative correlation between vertical jump and the 40-yd dash, $r=-0.651, n=12, p<0.05$, with high scores in the vertical jump associated with faster sprint times. There was a strong, positive correlation between vertical jump and back squat, $r=0.875, n=12, p<0.01$, with high scores in the vertical jump associated with improved back squat performance. Similarly, there was a strong, positive correlation between the vertical jump and power clean, $r=0.753, n=12, p<0.05$, with high scores in the vertical jump associated with improved power clean performance. There was a moderate, positive correlation between back squat and power clean, $r=0.697, n=12, p<0.05$, with high scores in the back squat associated with improved power clean performance. There was a strong, positive correlation between shoulder press and bench press, $r=0.876, n=14, p<0.01$, with high scores in the shoulder press associated with improved bench press performance.

DISCUSSION

The purpose of this study was to examine the effects of an 8-week concurrent strength and metabolic conditioning program on body composition, flexibility, speed, agility, anaerobic capacity, strength, and power performance in female high school soccer players. The results demonstrated concurrent strength training and metabolic conditioning increased multiple performance and strength measures. After 8-weeks of concurrent training, female high school soccer players significantly improved vertical jump height, pro agility test times, 40-yd sprint times, and 5-RM load during the back squat, power clean, shoulder press, and bench press, compared to pre-training values (Tables 5 and 6).

Anthropometrics

Mean body fat percentage increased from pre- to post-testing, indicating the concurrent training program did not result in favorable changes in body composition. These results are similar to several studies that also found no significant favorable changes in body fat percentage or fat-free mass after resistance training and high-intensity interval training (HIIT) for youth soccer players.^{1,2,10} The findings of the current study contradict Davis et al^{11,12} who report-

Table 5. Effects of 8 Weeks of Training on Performance Measures

	Pre (n=10)	Post (n=10)
Vertical jump (in)	17.9±3.2	19.2±2.3*
Sit and reach (cm)	35.3±6.7	34.6±5.7
Pro agility test (s)	5.36±0.3	5.01±0.3*
40yd sprint (s)	5.9±0.3	5.5±0.3*
300yd shuttle (s)	58.9±4.4	59.2±4.3

Values are mean±SD.
*Significant difference between pretests and posttests at $p \leq 0.05$.

Table 6. Effects of 8 Weeks of Training on Strength Measures

	Pre (n=14)	Post (n=14)
Back squat (lbs)	90±11.6	150±27.6*
Shoulder press (lbs)	46.1±11.6	77.5±15.5*
Power clean (lbs)	68.9±12.1	89.6±14.6*
Bench press (lbs)	63.2±13.5	80.7±13.8*

Values are mean±SD.
*Significant difference between pretests and posttests at $p \leq 0.05$.

ed decreased body fat percentage and increased lean mass in female college soccer players after 11 weeks of concurrent strength and endurance training. Miller et al¹³ similarly demonstrated that a power-based complex training program in collegiate female soccer players resulted in increased lean mass and decreased fat mass. Unfavorable changes in body fat percentage in the current study may be due to the lack of any nutritional intervention, the short time frame of the study, or lack of long aerobic endurance training during the training sessions.

It is notable that there were no significant changes found in total body mass or lean body mass from pre- to post-testing. This indicates there was not an increase in cross-sectional area due to muscular hypertrophy during the 8-week program. The concurrent training protocol used low volume and heavy resistance exercises, followed by HIIT-style metabolic conditioning, which has been shown to effectively minimize an interference effect between strength and aerobic training.³ Therefore, the strength gains resulting from the concurrent training program in this study are more likely attributed to neural adaptations rather than muscular hypertrophy.

Performance Measures

Flexibility: While not a specific focus of the training program, no significant changes in lower body flexibility were found after 8 weeks of concurrent training. This contradicts Davis et al^{11,12} who found an 8.4% increase in flexibility in female college soccer players after 11 weeks of concurrent strength and endurance training. Although, training sessions included dynamic warmups, mobility exercises, and static stretching it is more important to note that there was no significant reduction in flexibility across the 8-weeks.

Agility, power, and speed: Performance measures for power, speed, and agility all significantly improved. These results are similar to previous studies that determined resistance training was an effective protocol for developing speed and power.^{14,15} Chelly et al¹⁵

demonstrated that 8-weeks of heavy resistance training improved power output, jumping, and sprinting performance in junior soccer players without a significant increase in muscle cross-sectional area. Alves et al¹⁴ also reported improvements in the vertical jump, 5-m sprint, and 15-m sprint performance after combined resistance and plyometric training in young soccer players. Other studies have shown similar improvements in speed performance, but not in the vertical jump height. Sperlich et al² reported 5 weeks of HIIT in junior soccer players resulted in significant increases in VO_{2max} and sprint performance, but found no significant changes in vertical jump height nor did they report any negative impact of HIIT on sprinting or jumping abilities. Jullien et al¹⁶ found that heavy squat training alone (compared to agility training) did not improve field-based sprinting or agility performance in male professional soccer players. However, a combination of technical, agility, and speed training was suggested to be an effective alternative to a traditional strength program.¹⁶ Similarly, Siegler et al¹⁷ reported significant improvements in 20-m sprint times, but nonsignificant changes in the vertical jump in female high school soccer players after 10 weeks of combined resistance training, HIIT, and plyometric training.

Anaerobic Capacity

No significant changes were found pre- to post-testing in the 300-yd shuttle times. Previous studies have found that concurrent strength and endurance training protocols resulted in higher glycolytic enzymes and impaired oxidative enzyme activity, which may impact aerobic performance.^{3,5,18} However, as previously mentioned, the subjects in the current study did not display increased hypertrophy so an interference effect was unlikely. More likely, lack of improvement in this area may have been due to the training age of the subjects or the length and nature of the concurrent training program. Metabolic conditioning sessions in the current study focused on combined strength training and cardiovascular activities, with distances ranging from 200-m to 400-m. Subjects also performed speed and agility drills that focused on change of direction and sprinting mechanics. These exercises may not have been

specific to the 300-yd shuttle run which consisted of short 25-yd intervals with multiple changes of direction. No significant negative effect was found on anaerobic capacity in this study, however, implementing longer sprinting intervals with changes in direction may change this result in future studies. Measuring specific enzyme activity or including aerobic endurance testing is also recommended for future research.

Strength Measures

Muscular strength (back squat, shoulder press, and bench press) and power (power clean) significantly increased after 8 weeks of concurrent training. Increase in the back squat and power clean were strongly related to improvement in vertical jump height. Improvements in the back squat also corresponded to power clean performance. Improvements in the shoulder press were correlated with increased strength in the bench press. These findings are similar to previous studies that have presented high correlations between increases in strength and explosive performance,^{3,19} both in response to concurrent training methods and in response to traditional strength training.

Similar to previous research,^{2,3} the significant increases in strength found herein may be attributed to efficiencies in neural adaptations rather than hypertrophy. While this claim is limited by the lack of a comparison group in the current research, this was hypothesized based on the length of the study, the training protocol, and the lack of change in lean body mass. As shown by Wong et al³ the combination of intermittent HIIT-style conditioning and high load, lower rep resistance training may minimize the interference effect of training multiple modalities together. Future research should consider the measurement of muscle cross-sectional area in order to provide more precise data. Further recommendations also include performing this research with larger sample populations (both male and female) and the comparison of a traditional soccer endurance training group to a concurrent training group.

CONCLUSION

This is the first study to examine a concurrent strength and metabolic conditioning training program to improve performance in high school female soccer players. Based on these results, strength and conditioning coaches should implement a preseason concurrent strength and metabolic conditioning program to improve soccer players' explosive strength and performance. The reported interference effect of concurrent strength and aerobic training should be further studied to specify whether training protocols with low volume and high loads (3 sets of 5-RM) improve neural adaptations and avoid muscular hypertrophy. Instead of traditional aerobic endurance training, HIIT-style metabolic conditioning has been shown to improve speed and agility, and may be more specific to the energy systems used in soccer.²¹ When implementing metabolic conditioning programs, strength and conditioning coaches should make sure factors such as work intervals, intensity, and recovery intervals are specific to the energy – demands required during a soccer game.

The current study was implemented during the preseason

period, which avoids unwanted fatigue or interference with competitions matches.^{20,21} Concurrent training is recommended for offseason or preseason programming due to high training load. Further research should investigate the impact of an in-season concurrent training program on fatigue and overtraining, especially in young athletes.

APPENDIX A

Flexibility

Following the general warm-up, the flexibility of the hamstrings and lower back was measured using the sit and reach test. A sit and reach box (Fabrication Enterprises, White Plains, NY, USA) was used, and the athletes were given a period to stretch as needed before testing. The athletes were instructed to remove their shoes and place the soles of their feet on the base of the sit-and-reach box, and to keep their legs flat at all times. Then, while exhaling, the athletes reached their hands as far as possible along the measuring stick portion of the box in a controlled motion until the farthest point was reached. No bouncing or improper technique was allowed. The farthest distance reached out of the best of three trials was recorded in inches for each athlete.

Agility

The Pro Agility Test was used to assess agility. The test was performed on the soccer field and all athletes wore soccer cleats. Set-up consisted of three parallel cones placed 5 yards apart in a horizontal line. The athlete began the test at the center cone. When given an auditory signal from the researcher, the athlete sprinted 5 yards to the cone on the left, changed direction and sprinted 10 yards to the cone on the right, and changed direction to sprint 5 yards through the center cone, completing the test.²¹ The better of two timed trials were recorded for each athlete.

Power

For power, a maximal vertical jump test was performed using a Vertec Device (Perform Better, West Warwick, RI, USA). The athletes started the test in the standing position, and performed a vertical countermovement jump with arm swing. Vertical jump height was determined by the displacement of vanes on the Vertec device. Each athlete performed three trials, and the best jump height was recorded to the nearest 0.5 inches.

Speed

To test speed, a 40-yd dash was performed on a flat, pre-marked athletic track. The athletes wore athletic shoes for this test, and were allowed one submaximal practice run before performing one recorded time trial. On an auditory signal, the athletes sprinted a distance of 40 yards at maximal speed and their time was recorded to the nearest 0.1 second.

Anaerobic Capacity

To measure anaerobic capacity, a 300-yard shuttle run was per-

formed on a soccer field between two marked parallel 25-yard lines. On an auditory signal, the athletes sprinted from the starting line to the 25-yard line, then turned and sprinted back to the starting line until six round trips were completed (equaling 300 yards).²¹ The athletes completed one trial, and times were recorded to the nearest 0.1 second.

Strength Testing Procedures

Maximal strength testing took place over three non-consecutive days. Testing and training were supervised by the researcher and team coach. The researcher provided instruction for each lift, and the athletes followed the warmup protocol described by the National Strength and Conditioning Association (NSCA)²¹ to prepare for the maximal effort and to ensure technical competency before testing. Measurements consisted of a 5-repetition back squat, shoulder press, and bench press, and a 3-repetition power clean. The maximal weight the athlete could lift for 5 and 3 consecutive repetitions was recorded.²¹ The back squat and shoulder press were tested on Monday, the power clean was tested on Wednesday, and the bench press was tested on Friday. The researcher supervised the testing sessions to ensure that safety and correct lifting technique was followed. Detailed procedures for each strength test are described below.

Back Squat

Athletes warmed up for all of the maximal lifts by following the protocol described by the NSCA.²¹ For the back squat, athletes began with a loaded barbell on their back. Athletes were instructed to bend their knees to descend into the bottom position of the squat and then extend their legs to return to the standing position. Two spotters were present, and utilized the necessary spotting technique described by the NSCA.²¹ Five consecutive repetitions were performed at maximal weight and recorded as the 5-RM load for each athlete.

Shoulder Press

To perform the shoulder press, the athletes began in the standing position with a loaded barbell held in the front-rack position across their shoulders. Athletes were instructed to extend their arms overhead, lifting the barbell, using only their upper body. In the return phase, the bar was lowered back into the front rack position. Five consecutive repetitions were performed at the maximal weight and recorded as the 5-RM load for each athlete.

Power Clean

For the power clean, athletes set up their feet behind the barbell positioned on the floor, and bent down to establish their grip on the barbell. Athletes lifted the barbell off of the ground by extending their legs and forcefully extending their hips, while shrugging and pulling their arms underneath the barbell. Athletes received the barbell in the catch position by bending their knees in a quarter-squat, pulling their body underneath the barbell, and catching the barbell in the front-rack position. Athletes completed the lift by extending their legs to return to the standing position. Three

consecutive repetitions were performed at the maximal weight and recorded as the 3-RM load for each athlete.

Bench Press

Athletes set up for the bench press by lying flat on the bench, and grasping the barbell on the rack with a closed, pronated grip. The athlete then fully extended their arms and lifted the barbell off the rack to come to the starting position. Next, athletes lowered the barbell all the way to their chest then forcefully extended their arms to lift the barbell back up to the starting position. Five consecutive repetitions were performed at the maximal weight and recorded as the 5-RM load for each athlete. A spotter was always present and utilized proper spotting technique described by the NSCA.²¹

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

- Dupont G, Akakpo K, Berthoin S. The effect of in-season, high-intensity interval training in soccer players. *J Strength Cond Res.* 2004; 18(3): 584-589.
- Sperlich B, De Marées M, Koehler K, Linville J, Holmberg HC, Mester J. Effects of 5 weeks of high-intensity interval training vs. volume training in 14-year-old soccer players. *J Strength Cond Res.* 2011; 25(5): 1271-1278. doi: [10.1519/JSC.0b013e3181d67c38](https://doi.org/10.1519/JSC.0b013e3181d67c38)
- Wong PL, Chaouachi A, Chamari K, Dellal A, Wisloff U. Effect of preseason concurrent muscular strength and high-intensity interval training in professional soccer players. *J Strength Cond Res.* 2010; 24(3): 653-660. doi: [10.1519/JSC.0b013e3181aa36a2](https://doi.org/10.1519/JSC.0b013e3181aa36a2)
- Docherty D, Sporer B. A proposed model for examining the interference phenomenon between concurrent aerobic and strength training. *Sports Med.* 2000; 30(6): 385-394. doi: [10.2165/00007256-200030060-00001](https://doi.org/10.2165/00007256-200030060-00001)
- Glowacki SP, Martin SE, Maurer A, Baek W, Green JS, Crouse SF. Effects of resistance, endurance, and concurrent exercise on training outcomes in men. *Med and Sci Sports and Exer.* 2004; 36(12): 2119-2127.
- Faigenbaum AD, Kraemer WJ, Blimkie CJ, et al. Youth resistance training: Updated position statement paper from the national strength and conditioning association. *J Strength Cond Res.* 2009; 23: S60-S79. doi: [10.1519/JSC.0b013e31819df407](https://doi.org/10.1519/JSC.0b013e31819df407)
- Faigenbaum AD, Myer GD. Resistance training among young athletes: Safety, efficacy and injury prevention effects. *Br J Sports Med.* 2010; 44(1): 56-63. doi: [10.1136/bjism.2009.068098](https://doi.org/10.1136/bjism.2009.068098)

8. Faigenbaum AD, Westcott WL, Loud RL, Long C. The effects of different resistance training protocols on muscular strength and endurance development in children. *Pediatrics*. 1999; 104(1): e5-e6.
9. American College of Sports Medicine. 9th ed. *ACSM's Guidelines for Exercise Testing and Prescription*. Baltimore, MD, USA: Lippincott Williams & Wilkins; 2013.
10. Christou M, Smilios I, Sotiropoulos K, Volaklis K, Pilianidis T, Tokmakidis SP. Effects of resistance training on the physical capacities of adolescent soccer players. *J Strength Cond Res*. 2006; 20(4): 783-791.
11. Davis WJ, Wood DT, Andrews RG, Elkind LM, Davis WB. Concurrent training enhances athletes' strength, muscle endurance, and other measures. *J Strength Cond Res*. 2008; 22(5): 1487-1502. doi: [10.1519/JSC.0b013e3181739f08](https://doi.org/10.1519/JSC.0b013e3181739f08)
12. Davis WJ, Wood DT, Andrews RG, Elkind LM, Davis WB. Concurrent training enhances athletes' cardiovascular and cardiorespiratory measures. *J Strength Cond Res*. 2008; 22(5): 1503-1514. doi: [10.1519/JSC.0b013e3181739f9f](https://doi.org/10.1519/JSC.0b013e3181739f9f)
13. Miller J, Koh Y, Park CG. Effects of power-based complex training on body composition and muscular strength in collegiate athletes. *J Sports Sci and Med*. 2014; 2(5): 202-207.
14. AlvesJM, Rebelo VM, AbrantesC, Sampaio J. Short-term effects of complex and contrast training in soccer players' vertical jump, sprint, and agility abilities. *J Strength Cond Res*. 2010; 24(4): 936-941. doi: [10.1519/JSC.0b013e3181c7c5fd](https://doi.org/10.1519/JSC.0b013e3181c7c5fd)
15. Chelly MS, Fathloun M, Cherif N, Amar MB, Tabka Z, Van Praagh E. Effects of a back squat training program on leg power, jump, and sprint performances in junior soccer players. *J Strength Cond Res*. 2009; 23(8): 2241-2249. doi: [10.1519/JSC.0b013e3181b86c40](https://doi.org/10.1519/JSC.0b013e3181b86c40)
16. Jullien H, Bisch C, Largouët N, Manouvrie C, Carling CJ, Amiard V. Does a short period of lower limb strength training improve performance in field-based tests of running and agility in young professional soccer players? *J Strength Cond Res*. 2008; 22(2): 404-411. doi: [10.1519/JSC.0b013e31816601e5](https://doi.org/10.1519/JSC.0b013e31816601e5)
17. Siegler J, Gaskill S, Ruby B. Changes evaluated in soccer-specific power endurance either with or without a 10-week, in-season, intermittent, high-intensity. *J Strength Cond Res*. 2003; 17(2): 379-387.
18. Bell GJ, Syrotuik D, Martin TP, Burnham R, Quinney HA. Effect of concurrent strength and endurance training on skeletal muscle properties and hormone concentrations in humans. *Eur J Appl Phys*. 2000; 81(5): 418-427. doi: [10.1007/s004210050063](https://doi.org/10.1007/s004210050063)
19. Wisløff U, Castagna C, Helgerud J, Jones R, Hoff J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *Br J Sports Med*. 2004; 38(3): 285-288. doi: [10.1136/bjism.2002.002071](https://doi.org/10.1136/bjism.2002.002071)
20. Ronnestad BR, Kvamme NH, Sunde A, Raastad T. Short-term effects of strength and plyometric training on sprint and jump performance in professional soccer players. *J Strength Cond Res*. 2008; 22(3): 773-780. doi: [10.1519/JSC.0b013e31816a5e86](https://doi.org/10.1519/JSC.0b013e31816a5e86)
21. Haff GG, Triplett NT, eds. *Essentials of Strength Training and Conditioning*. 4th ed. Champaign, IL, USA: Human Kinetics; 2016.