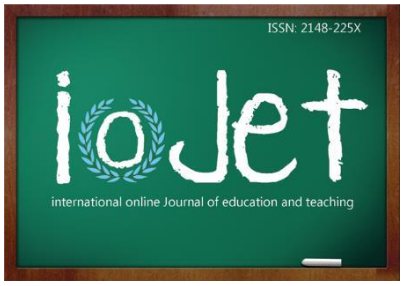

Erol, S. (2022). An investigation of the effects of 8-week complex and contrast strength trainings applied to soccer players on some physical properties. *International Online Journal of Education and Teaching (IOJET), 9*(4). 1600-1613.

Received : 04.06.2022
Revised version received : 08.08.2022
Accepted : 10.08.2022

AN INVESTIGATION OF THE EFFECTS OF 8-WEEK COMPLEX AND CONTRAST STRENGTH TRAININGS APPLIED TO SOCCER PLAYERS ON SOME PHYSICAL PROPERTIES

(Research article)

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Abstract

The aim of present study was to investigate the effect of 8-weeks complex and contrast training applied to soccer players on selected physical Characteristics. A total of 23 university students playing soccer in the university team participated in the study voluntarily. Subjects were randomly divided into two groups; complex (CPX) and contrast (CNT) training protocols. During 8-weeks, CPX and CNT training groups performed strength training in addition to soccer training 2 days a week, over 7 hours (4-5 units). On the first day, one repetition maximum (1RM) strength tests (back squat, calf, and leg extension) of all subjects were measured respectively. On the second day, all athletes' height, body weight, body fat ratio, (20m) sprint, vertical jump and agility performance tests were measured at the beginning and end of the 8-weeks study. As a result of the analysis of the data, a statistically significant difference was found in the values of the first and last measurements (1RM test) (back squat, calf and leg extension) between the groups of the CPX strength training group subjects and CNT strength training group ($p < .05$). There was no statistically significant difference between the groups in speed (20m), vertical jump, agility and smash dive performance tests ($p > .05$). Although these results are not thought to be conclusive yet, there may be important information for coaches, especially during the training prescription and physical performance control of football players.

Keywords: Football; Complex; Training; Contrast Training, Strength, Sprint

1. Introduction

An optimal level of physical fitness is one of the prerequisites for success of elite athletes. The main components of soccer-specific physical fitness include acceleration, anaerobic repetitive sprinting ability, and the explosive strength. These components are associated with force generation, especially during running, turning, hitting the ball, jumping, and maintaining balance (Psotta et al, 2011; Stolen, Chamari, Castagna, & Wisloff, 2005). More specifically, soccer is considered to be a branch of sports played by combining intermittent movements in motion analysis (Di Salvo et al, 2005). For example, in a typical soccer game, players perform short actions every 3–5 seconds, with 30-40 sprints, 30-40 jumps. These are actions such as slowing down from the original direction as quickly as possible and accelerating in a new direction, jumping, hitting the ball, and dribbling, (Bangsbo, 1994; Morh et al, 2005). The optimization of these actions mentioned above and related factors are more important as the high-intensity soccer actions and activities increase in today's competitive soccer matches (Bush, Barnes, Archer, Hogg, & B, Bradley, 2015). In this line, the main aim of strength training was to improve the technical and tactical capacity of the players in order to execute their soccer abilities and the game (Brito, Vasconcellos, Oliveira, Krustrup, & Rebelo, 2014). Accordingly, different resistance training models have been used to improve physical performance in soccer (Kotzamanidis, Chatzopoulos, Michailidis,

Papaiakovou, & Patikas, D. 2005). Strength and strength training programs have been shown to be effective in improving the athletic abilities mentioned in team sports players (Bauer et al., 2009). Some of the neuromuscular aspects underlying these positive adaptations may be related to changes in physiological mechanisms, morphological factors, and neural factors (motor unit) (Cormie, Mc Guigan, & Newton, 2011).

Complex (CPX) and contrast (CNT) strength training methods are examples of unconventional strength training practices used by strength and conditioning trainers to increase the power outputs further to the typical gains expected from the traditional methods in soccer (Verkhoshansky, 2002; Manuel et al, 2010). It has been stated that CPX and CNT strength training have been stated to be effective in increasing the performance ability of lower extremities in team sports (Cormie, Mc Guigan, & Newton, 2011). Both methods combine strength and strength / plyometric exercises in the same training session, however, although the CPX and CNT training terms are sometimes used interchangeably, moreover, there is a difference between these methods in terms of order of the exercise within the session. The CPX training alternates biomechanical similar high-load weight training with plyometric exercises, set for set, in the same workout (Baker, & Newton, 2005; Franchi Reeves, & Narici, 2003). Complex training is based on the performance of a strength exercise, usually resistance-based, and then a plyometric exercise. Strength and plyometric exercise are generally biomechanically similar, meaning that they move with a similar range of motion. CNT training is the method in which sets of heavy resistance exercises are replaced with a lighter explosive exercise on a set-by basis (Duthie et al, 2002).

When reviewed the studies conducted on the development of explosive power outputs in the literature, generally the concept of "optimal loading" has been used (Cronin, 2005). Gravitational exercises that have been used to improve physical performance in soccer, which are similar to sports-based traditional programs, include plyometric exercises, ballistic exercises, weight training with submaximal and maximal loads, or a combination of these methods (Faude, Roth, Giovine, Zahner, & Donath, 2013).

However, although the popularity of CPX and CNT strength training methods has increased recently, it has seen that most of the recent studies conducted on soccer have investigated the effects of short-term training planning (6-11 weeks).

Both CPX and CNT methods are described as an acute increase in the strength-building capacity of skeletal muscle as a result of a biomechanically similar "conditioning activity" (Tillin, & Bishop, 2009).

Soccer is a team sport, therefore, most of the training programs implemented included activities aimed at improving the level of physical fitness of athletes needed during the matches. Coaches may feel the need to rationalize the time and volume allocated to strength training programs as a strategy to ensure that players are successful in their proposed training program. Thus, we hypothesized that CPX training may be more effective than CNT since it is a method that follows a higher explosive exercise set followed by optimal resistance exercise sets. In the current study, therefore, we aimed to investigate the effects of 8-weeks CPX and CNT strength training on players' strength,20 m sprint, agility and vertical jump (VJ) performance in soccer. This pilot study provides information on the feasibility and feasibility of CPX and CNT training developed for football players. The progress in football in the last decade resulted in e.g. increased physical contact between players. In view of the

technological and scientific developments that often exceed the physiological limits in order to increase the players' performance (Gümüşdağ et al., 2011).

Problem of the Study

The primary and secondary problems of this study are as follows:

Problem: What are the effect of 8-weeks complex and contrast training applied to soccer players on selected physical Characteristics?

Sub-problems of the study

- What is the effects of CPX and CNT strength training on players' strength performance?
- What is the effects of CPX and CNT strength training on players' 20 m sprint performance?
- What is the effects of CPX and CNT strength training on players' agility performance?
- What is the effects of CPX and CNT strength training on players' vertical jump performance?

2. Method

2.1. Participants

The conditions and purpose of the study were explained to 33 students who formed the Bursa Uludag University football team, and general information about the research was given. As a result, 28 football players agreed to participate in the study voluntarily. When the athlete history of the football players who accepted to participate in the study was examined, it was determined that they had an average of 5 years of training history. Five subjects were excluded from the study due to unwillingness to participate in the study since the first measurement, transfer to another team, illness, and not being able to follow the regular schedule. The study was completed with 23 subjects. All subjects reported being free from illness and injury at the time of the experiment. After the negatives and benefits, they may encounter during the applications were explained in detail, the subjects read and signed the consent form before the study. Those who wanted to quit the study of their own free will and those who experienced psychological or physical trauma during the study were excluded from the study. Also, those whose blood pressure and heart rate values before and after the exercise test were out of physiological levels were excluded from the study.

Ethics committee approval was obtained for the research from Bursa Uludag University, Health Sciences Research and Publication Ethics Committee with the decision numbered 2019 – 20/16 from the meeting on 04.12.2019.

2.2 Training design

Subjects were randomly divided into 2 groups according to the experimental protocols to be applied. CPX and CNT training Program was performed 3 days a week for 1 week and became familiar with the exercise procedures. During 8 weeks, in addition to a total of 7 hours (4-5 session) of soccer training per week, while one of the groups (CPX; n = 10)

performed CPX, the other group (CNT; n =13) performed CNT training for 3 days per week. CPX and CNT training programs are shown in Table 1.

In the CNT three exercise stations (ExSt-1, ExSt-2, ExSt-3) were chosen as followed: ExSt-1: 10 reps of a back squat exercise at 70% of 1RM, immediately followed by leg pull-in knee-ups statically for 6 seconds, and then a 5-meter sprint. ExSt-2: 7 reps of calf extension exercise at 80% of 1RM, immediately followed by 8 reps of vertical jumps, and then 3 reps of head kicks. ExSt-3: 5 reps of leg extension exercise at 85% of 1RM immediately followed by 6 reps of a vertical jump from the seating position, followed by falling from a height of 60 cm, and then 3 reps of head kicks (1 set). For the total of 3 sets, while the recovery was 2-4 minutes between the sets, it was 60 sec passive rest between stations. In the CPX training program, included same three exercise stations (ExSt-1, ExSt-2, ExSt-3): ExSt-1: 3 sets x 10 reps of a back squat exercise at 70% of 1RM, after 60 sec passive rest subjects performed 3 sets x 6 sec leg pull-in knee-ups statically, after 60 sec passive rest subjects performed 3 x 5-m sprint. 2-4 min. passive rest before starting next station. ExSt-2: 3 sets x 7 reps of calf extension exercise at 80% of 1RM, after 60 sec passive rest subjects performed 3 sets x 8 reps of vertical jumps, after 60 sec passive rest subjects performed 3 x 3 reps of head kicks. 2-4 min passive rest before starting next station. ExSt-3: 3 sets of 5 reps of leg extension exercise at 85% of 1RM, after 60 sec passive rest subjects performed 3 sets x 6 reps of a vertical jump from the seating position, after 60 sec passive rest subjects performed 3 sets x 3 falling from a height of 60 cm, and then head kicks., (table 1). The following tests were carried out by subjects as pre-test at the beginning and post-test at the end of the 8 wk experimental program.

Table 1. *Soccer CPX and CNT Training Program*

	CPX	CNT
ExSt-1	10 rep. back squat x 3 6 s leg pull-in knee-ups x 3 5 m sprint x 3	10 rep. back squat 6 s leg pull-in knee-ups 5 m sprint
ExSt-2	7 rep. calf extension x 3 8 rep. VJ x 3 3 rep. head kicks x 3	7 rep. calf extension 8 rep. VJ 3 rep. head kicks
ExSt-3	5 rep. leg extension x 3 6 rep. seating VJ x 3 3 rep. head kicks x 3	5 rep. leg extension 6 rep. seating VJ 3 rep. head kicks
Set	1	3
1 RM	ExSt-1 70% ExSt-2 80% ExSt-3 85%	ExSt-1 70% ExSt-2 80% ExSt-3 85%
Speed	High	High
Recovery	2-4 min between stations	2-4 min between sets
Type	Respectively	Cyclically

VJ: vertical jump; rep.: repetition; ExSt: exercise set.

2.3. Experimental design

Before and after the 8-weeks CPX and CNT training program, a 2-day test set, carried out out on non-consecutive days. On the first day height, weight and body fat % were measured then 1RM back squat, calf extension, and leg extension were determined respectively, second day 20 m sprint, agility and vertical jump tests were carried out. All tests were carried out out in the fitness center where the training program was performed, and two assistants necessarily helped the subjects during tests. Second day tests were performed twice for each participant and best performances were recorded. Before the tests, a general and specific warm-up was performed for 20 minutes. The subjects had not performed any intense training (loading) within 24 hours before the test (Fig 1. Flow chart of intervention).

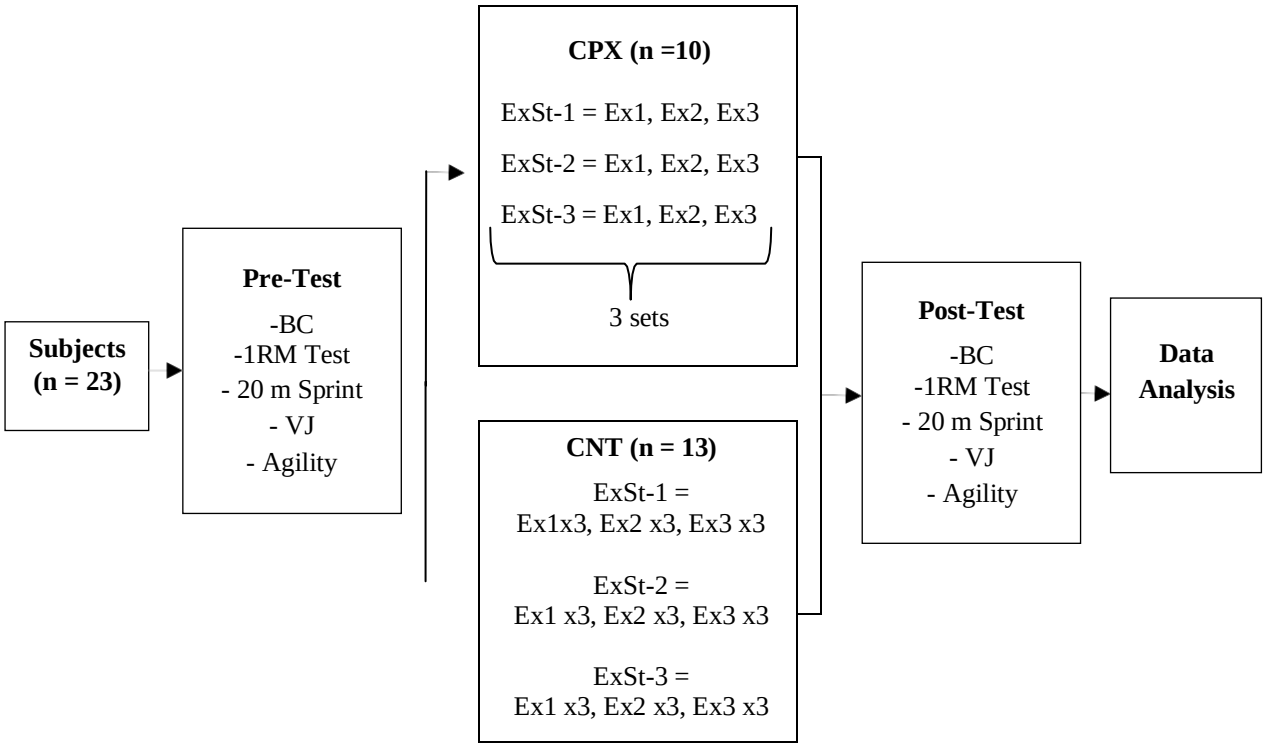

Figure 1. *Flow chart of intervention*

2.4. Body Composition

Body compositions of the participants were taken with the Tanita TBF-300 (Tokyo, Japan) analyzer.

2.5. 1 Repetition Maximum Tests

(1RM): 1 RM of the study was determined according to the Brzycki equation. According to this formula, 1RM is estimated as follows: 1RM= Weight ÷ (1.0278 - (0.0278 × Number of repetitions (Brzycki, 1993).

2.6. (20m) Sprint Test

After the 20 m distance was determined as a running track, 2 wireless Sinar (Turkey) brand photocells were installed. The subjects were asked to complete the limited distance of 20 m by running at maximal speed in the high starting position. The best score was obtained by

measuring the run time with a photocell in 'sec' and repeating the test twice (Mulazımoglu et al., 2009).

2.7. Agility Test

T test was used for agility measurement. Four cones are arranged in a T-arrangement. The athlete starts the run with the starting signal from point (a). From point (a) to point b, run straight, from part (b) to part c, from point to point C with a rock step and from part c to (d) with a slip step. (Scanlan et al,2021). This process is measured as time.

2.8. Vertical Jump Test

AS (Vertical Jump Test) was used for vertical jump test measurements. Standing with feet shoulder-width apart. The vertical jump from the squat position was performed maximally (Kamer, 2003). Athlete subjects performed 2 jumps. A 1 minute rest was applied between jumps. The higher of the two measurements was recorded as data.

2.9. Statistical analysis

ANOVA was applied for repeated measurements after the pre- and post-test of the complex and contrast training group, work/set paired within the groups, and work was evaluated at $p < 0.05$ using the t test.

3. Findings

In present study, the effects of 8-weeks CPX and CNT strength training on some physical fitness characteristics of soccer players (lower extremities) were investigated. The differences between pre-test and post-test variables are presented in Table 2.

Table 2. *Comparison of descriptive characteristics of CPX and CNT subjects.*

Variables	**CPX (n = 10)**				**CNT (n =13)**			
	Mean ± SD		Min		Mean ± SD		Min	Max.
	Pre	Post	Max.		Pre	Post		
Age (years)	21.3 ± 0.8	21.3 ± 0.8	20	23	23.1 ± 1.7	23.1 ± 1.7	21	27
Height (cm)	178 ± 7.7	178 ± 7.7	163	185	175.8 ± 7.8	175.8 ± 7.8	165	188
Weight (kg)	68,2 ± 5.5	68.2 ± 4.6	59.6	89. 5	69.5 ± 8.9	69.5 ± 9	52.9	84.2
BMI (kg/m^2)	21.5 ± 1.1	21.5 ± 1.6	19.9	21. 9.	22.2 ± 2.6	22.2 ± 2.3	18.3	26

As shown in Table 2 descriptive characteristics of CPX and CNT (mean ± SD) age 21.3±0.8 years and 23.1±1.7 years, height 178±7.7 cm and 175.8±7.8 cm, weight 68.2±5.5 kg and 69.5±8.9 kg, BMI 21.5±1.1 kg /m^2, and 22.2±2.3 kg /m^2 respectively were determined.

Table 3. *Comparison of the changes in 8-weeks CPX and CNT training between groups according to pre-test and post-test measurements.*

Variables	CPX (n = 10)		CPX (n =13)				
	Pre-test Mean ± SD	Post-Test Mean ± SD	Pre-test Mean ± SD	Post-Test Mean ± SD	F	$_{partial}^2$	Cohen's d
Back Squat (kg)	97.10 ± 9.2	102.40 ± 9.2 †	89.54 ± 9.4	91.46 ± 8.4†	8.53*	0.469	1.87
Calf Extension (kg)	100.60 ± 13.7	106.30 ± 16.4†	100.23 ± 5.2	101.31 ± 5.1†	3.71*	0.395	1.61
Leg Extension (kg)	95.70 ± 7.4	100.50 ± 8.6†	76.46 ± 12.7	78.00 ± 12.2†	6.87*	0.446	1.79
(20m) Sprint (sec)	3.19 ± 0.18	3.06 ± 0.13†	3.22 ± 0.22	3.17 ± 0.24†	4.067	0.162	0.87
T-agility (sec)	10.02 ± 1.42	9.97 ± 1.52	9.78 ± 0.70	9.99 ± 1.27	0.734	0.034	0.37
VJ (cm)	48.80 ± 5.7	50.50 ± 4.06†	43.08 ± 7.9	44.23 ± 8.07†	0.684	0.032	0.36

*= p<0,05

According to the analysis results in table 3, a statistically significant difference was found between the groups in favor of the CPX training in back squat (pre 97.10±9.2 kg - post 102.40±9.2 kg vs. CNT pre 89.54±9.4 kg - post 91.46±8.4 kg) calf extension (pre 100.60±13.7 - post 106.30±16.4 kg vs. CPX pre 100.23±5.2 kg - post 101.31±5.1 kg) and leg extension (pre 95.70±7.4 kg - post 100.50±8.6 kg vs. CNT pre 76.46±12.7 kg - post 78.00±12.2 kg).

However, there was no significant difference between CPX and CNT in the (20m) sprint (CPX pre 3.19±0.18 sec - post 3.06±0.13 sec vs. CNT pre 3.22±0.22 sec - post 3.17±0.24 sec), T-agility (CPX pre 10.2±1.42 sec - post 9.97±1.52 sec vs. CNT pre 9.78±0.70 sec - post 9.99±1.27 sec), vertical jump (CPX pre 48.80±5.7 cm - post 50.59±4.06 cm vs. CNT pre 43.08±7.9 cm - post 44.23±8.08 cm) values.

A statistically significant difference was found in the values of the first and last measurements (1RM test) (back squat, calf and leg extension) between the groups of the CPX strength training group subjects and CNT strength training group ($p < .05$). There was no significant difference between the groups in speed, vertical jump, agility and smash dive performance tests ($p > .05$).

4. Conclusion and Discussion

The present study was carried out particularly to evaluate the chronic effects of CPX and CNT training and to compare their effects on lower extremity muscles strength, (20m) sprint, agility and vertical jump. According to the main findings obtained from the 8-weeks study, although both CNT and CPX training provided significant improvement in lower extremity muscles strength (1RM back squat, calf and leg extension), CNT training was found to be significantly superior to CPX training in lower extremity muscle strength in comparison between groups. Also, both of CPX and CNT trainings showed significant increases in (20m) sprint and vertical jump skills in terms of time effect.

After 3 sets of each exercise were carried out at the CPX ExSt-1, the next station was performed respectively and all stations were performed one set in total, but at the CNT ExSt-1, each exercise was carried out 1 set then the next station was done, and all stations were performed cyclically 3 sets in total. As far as we know, this training method was carried out for the first time.

Talpey, Young, & Saunders, (2016) reported that 1RM 1⁄2 squats improved significantly in both traditional (23.3%) and complex (24.4%) training groups in nine weeks training with trained athletes. Duthie et al, (2002) in their study examining the effect of acute complex and contrast exercises on peak power output reported that complex protocols resulted in the lowest peak power outputs over 3 sets when compared to contrast and conventional protocols. In present study, it was found that CNT training had a significantly greater increase in lower extremity muscle strength than CPX training. CNT training is a strength training method supported by the assumption of the post activation potentiation of the neuromuscular system (Robbins, 2005) and it is claimed very effective to increase anaerobic power (Garcia et al, 2014). Load stimuli acting on the organism during CNT contraction training can activate different contraction regimes (Cometti, 1999). However, the similar results of vertical jump and 20m sprint despite significant improvements in strength compared to CPX in CNT training suggest that the volume or frequency of this method may be insufficient.

Includes the rationale that initial muscle contractions stimulate the motor unit and that myosin-regulating light chains affect phosphorylation, improving the Ca2±sensitivity of myofilaments, allowing greater power output biomechanically (Verhoshansky, 2002).

Talpey, Young, & Saunders, (2016) found a significant difference within-group improvement in 15–20 m sprint time in the complex training with trained athletes. García et al, (2014) reported that the 8-weeks CPX training they performed provided significant improvements in the 5-10-20-30 m sprint tests of young soccer players. Spineti et al, (2018) reported that 8 weeks of complex-contrast training was more effective on participants' squat jump, change of direction and 5m sprint performance than traditional strength training but similar results were obtained in the 10-20-30m sprint tests. However, in some studies investigating the effect of similar studies on the VJ parameter, for example, Mihalik et al, (2008) reported that improvement in the vertical jump height of experienced jumpers following a compound and complex training program, respectively (9.1%, 5.4%). Hammami et al, (2018) found significantly increases change of jumping (squat 19% and countermovement 20.3%) after 12 weeks complex training intervention with young handball players. In present study, significant increases were detected in both CPX and CNT training in (20m) sprint and VJ. The improvement (20m) sprint and VJ indicates that adaptations related to increases in leg

strength are taking place. These adaptations are likely to be neural, because strength and power training predominate in the initial phase of training, followed by plyometric exercise, which has been shown to promote main adaptation (Thomas, French, & Hayes, 2009). As plyometric exercise becomes dominant, it induces neuromuscular adaptations to the stretch reflex, which may lead to increased motor units during muscle contraction and increased performance in ballistic movements (Perez et al, 2008; Plisk, 2000). This would support the logic that neural changes could improve the ability to store and release elastic energy during the stretch-shortening cycle (Garcias et al, 2014). Psychophysiology factors are thought to be effective as the reason why there was no difference in T-agility performances in both CNT and CPX training in terms of time effect and group x time interactions.

The study was carried out with university soccer players, but the training levels of the subjects were not determined. Not knowing the training levels of the subjects and not including women and professional athletes are the main limitations of the present study. In these comparisons, the post-test values were found to be higher than the pre-test values. According to the results of the research, it is necessary to apply more long-term applications to increase the positive effect of 8-weeks basic game education at the levels of motor development in children aged 4 to 6 years old (Gümüşdağ, 2019). Bastık et al., (2012) in their study, the locomotors sub-test scores were examined according to the sports branches; the locomotors sub-test scores of children who participated in swimming, table tennis and soccer teams were found higher significant differences statistically than the another children who participated in competitions of taekwondo, tennis and handball teams, respectively.

The study was carried out with university soccer players, but the training levels of the subjects were not determined. Not knowing the training levels of the subjects and not including women and professional athletes are the main limitations of the present study.

As a result of the analysis of the data, a statistically significant difference was found in the values of the first and last measurements (1RM test) (back squat, calf and leg extension) between the groups of the CPX strength training group subjects and CNT strength training group ($p < .05$). Although these results are not thought to be conclusive yet, there may be important information for coaches, especially during the training prescription and physical performance control of football players.

5.1 Recommendations

The varsity men's soccer team is not very physically fit, but are getting more and more athletic. Running players need power to win a match or to control the ball before their opponents. Our results on young football players, conducted at a pivotal point during their competitive season, showed no difference in sprint, agility, vertical jump performances, even though a 8-WEEK training program mix both CPX and CNT showed only a difference in strength. However, it seems to encourage some athletic performance gains not seen with the CPX and CNT. Therefore, coaches should be planned to include CPX in-season conditioning. Although these results are not thought to be conclusive yet, there may be important information for coaches, during the training period and increase of physical performance of football players.

5.2 Ethical Text

All ethic rules were followed and ethical approval was obtained from the authorities.

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