Comparison of Complex Versus Contrast Training on Steroid Hormones and Sports Performance in Male Soccer Players

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ABSTRACT

Objective: The purpose of this study was to compare the effects of a complex versus a contrast training regimen with steroid hormones and the performance of soccer players.

Methods: Thirty-six professional male soccer players were randomly divided into 3 equal groups: complex training ($n = 12$; body mass index [BMI], $22.95 \pm 1.76 \text{ kg/m}^2$), contrast training ($n = 12$; BMI, $22.05 \pm 2.03 \text{ kg/m}^2$), and control ($n = 12$; BMI, $22.27 \pm 1.44 \text{ kg/m}^2$). Players from the complex and contrast groups were trained for 6 weeks (3 d/wk). The complex group performed 4 different exercises, each composed of strength (80% of 1 repetition maximum [RM]) and power components alternately. The contrast group performed the same strengthening exercises alternately at different intensities (40% and 80% of 1 RM). All players were tested for free testosterone, cortisol, vertical jump, 20-m sprint, and agility T-test at the baseline and after 6 weeks of training.

Results: A 3×2 mixed analysis of variance revealed a significant difference in time effect ($P \leq .05$), whereas a nonsignificant difference was found in the group effect for all outcome variables. group $\times$ time interaction was significant in all the variables ($P < .01$) except cortisol ($P = .28$).

Conclusion: Complex training showed greater improvement in physical performance and free testosterone concentration compared with contrast training, whereas both types of training decreased cortisol concentration in a similar fashion. (J Chiropr Med 2019;18:131-138)

Key Indexing Terms: Resistance Training; Testosterone; Hydrocortisone; Plyometric Exercise

INTRODUCTION

Combining different modes of exercises in a training session is popular among the athletic population in an attempt to reach the demands of games and to increase performance. However, a high-intensity regimen places a tremendous amount of stress on the neuromuscular and endocrine systems.¹ Steroid hormones like testosterone (T) and cortisol (C) are extremely sensitive to physical stress, and their ratio has been used to detect overtraining.² Thus, it becomes

imperative to measure the hormonal levels when new modes of exercises are incorporated in a training regimen.

Complex training incorporates power exercise before the execution of biomechanically similar strength exercise, set-for-set basis, in the same session. It is believed that complex training enhances the quality of the plyometric training stimulus.³ This tactic involves a physiologic rationale called *postactivation potentiation* (PAP) in which the previous contraction stimulates the motor unit excitability and phosphorylation of myosin regulatory light chains, which increases Ca^{2+} sensitivity of the myofilaments, allowing a greater power output in the next biomechanically similar movement.⁴ Contrast training uses 2 different modes of loading in the same session; these modes use the PAP effect by using the same exercise modality performed at varying intensities.⁵ This alteration of light loads with heavy ones allows for the execution of more explosive movements, as a preceding bout has a precondition effect in the subsequent explosive movements for maximal effort.² Previous literature shows the positive effects of complex and contrasting modes of training on athletic performance and the anabolic physiologic profile for adaptation.^{2,4,6-9}

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A number of studies of complex training were acute adaptation studies that analyzed the effect of, for example, load alteration and rest period on power and strength performance along with its relationship to T and C concentration.¹⁰⁻¹² Acute changes have been accounted for, and from this, researchers have sought to apply the results to the training regimens for athletes. It is accepted that acute enhancement in T increases nutrient segregation into tissue and protein synthesis,¹³ whereas acute raise in C concentration leads to tissue catabolism to promote energy mobilization.¹⁴ Thus, equilibrium and timing between anabolic and catabolic hormones, and availability of the necessary nutrients and proteins, are thought to be vital for muscle growth.¹⁵ Kraemer et al¹⁶ showed that specific loading parameters of resistance exercise affect endocrine response, and growth hormone secretion is sensitive to hypertrophy protocols (high total work, moderate loads, and short rest periods) and causes relatively large increases in serum total T concentration. Hansen et al¹⁷ reported that leg exercises acutely increase anabolic hormones, which relatively enhance the isometric strength. Staron et al¹⁸ have described the relationship between the muscle fiber transformation and increase in the strength to increased serum T levels. However, studies comparing the effect of these 2 modes on endocrinal physiology are scarce. Thus, there is a need to explore how the 2 different modes of exercise have long-term effects on endocrine hormones and athlete performance.

Whether strength or power bout is a superior mode of preconditioning exercise to maximize the PAP can be analyzed by comparing both types of training. Therefore, the purpose of the present study is to compare the effects of complex versus contrast training on physical performance and their adaptation with respect to free testosterone (FT) and cortisol concentrations in soccer players.

MATERIALS AND METHODS

Participants

After obtaining approval from the institutional ethics committee of the Jamia Millia Islamia and trial registered in clinical trials registry of India (Indian Council of Medical Research; registration number CTRI/2017/09/009631), 36 male players from a university soccer team were selected for the study. Eligibility criteria were as follows: male athletes had 4 to 5 years of experience, had played at the university level at least, were able to squat 1.5 times their body weight (lower limb strength), and could do 5 repetitions of back squats with 60% of body weight in 5 seconds or less (lower limb speed), per the guidelines of National Strength and Conditioning Association.¹⁹ The athletes were informed about the purpose, training risks, and the benefits of the study. Each athlete provided a written informed consent before the beginning of the study procedures. Participants were enrolled during the off-

season to eliminate the effects of any other sport-specific drills and competitive play. They were randomly allocated to a complex group (n = 12; body mass index [BMI], 22.95 ± 1.76 kg/m²), a contrast group (n = 12; BMI, 22.05 ± 2.03 kg/m²), or a control group (n = 12; BMI, 22.27 ± 1.44 kg/m²) through block randomization with a variable block size and the allocation ratio of 1:1 using a list of random numbers generated by Ralloc software before familiarization.

Experimental Procedure

All athletes from the complex and contrast groups underwent familiarization for 2 weeks, incorporating 6 sessions; each session included 3 sets of 12 repetitions. The intensity during this period was maintained at 40% to 60% of 1 repetition maximum (RM). It was necessary to adapt the athletes to proper technique, and the risk of possible injuries was reduced during the execution of the main training protocol. All participants were given 72 hours of rest (after familiarization) and then a baseline assessment for leg power, speed, agility, and steroid hormones was undertaken.

Interventions

The exercise was conducted 3 times per week for 6 weeks (total 18 sessions). Each session was composed of 10 minutes of warm-up followed by the training regimen and then 8 minutes of cooldown. Training regimens for the complex and contrast group are described in Table 1. The exercises were identical regarding their biomechanics for both groups. Proper exercise technique was ensured by the researcher before advancing the participants. Progression was done by increasing weights (strength exercises) and height (plyometric exercises). The control group did not receive any specific exercise protocol; however, they were allowed to continue their soccer training routine.

Testing Evaluation

Participants attended 3 data collection sessions. On their first visit, they were evaluated for a complete physical fitness including their BMI. Each participant also attended an orientation session to be familiar with the testing procedures and warm-up techniques. Outcome measures were sequentially collected with blood sample collection followed by countermovement jump (CMJ), 20-m sprint, and agility T-test both at baseline and after 6 weeks of training for all groups. All athletes received proper rest between the test and their trials; 20-m sprint and agility T-test were conducted on a grass field, whereas CMJ was performed in indoor settings. Practice trials were required to diminish potential learning effects.²⁰ In addition to maintaining measurement reliability, the goal was to use field tests related to soccer performance.

Free-Testosterone and Cortisol. Blood samples from the athletes were collected in the beginning and at the end of the

Table 1. *Exercise Protocols*

Phase 1: Warm-up (10 minutes)		
2 to 3 minutes jogging and low-intensity strides, jumping, and bounding		
5 to 7 minutes dynamic stretching of lower limb muscles (quadriceps, hamstring calf)		
Phase 2: Main phase		
Group	Exercise	Sets × Repetitions
Complex training	Squats (80% 1 RM)	3 × 12
	Depth jumps	3 × 12
	Barbell lunge (80% 1 RM)	3 × 12
	Split squat jumps	3 × 12
	Lateral lunge (80% 1 RM)	3 × 12
	Lateral hops	3 × 12
	Calf raise (80% 1 RM)	3 × 12
	Calf jumps	3 × 12
Contrast Training	Squats (40% 1 RM)	3 × 12
	Squats (80% 1 RM)	3 × 12
	Barbell lunge (40% 1 RM)	3 × 12
	Barbell lunge (80% 1 RM)	3 × 12
	Lateral lunge (40% 1 RM)	3 × 12
	Lateral lunge (80% 1 RM)	3 × 12
	Calf raise (40% 1 RM)	3 × 12
	Calf raise (80% 1 RM)	3 × 12
Phase 3: Cool-down		
5-minute walk		
3-minute stretching		

Recovery times between repetitions and sets were 30 and 60 seconds, respectively
RM, repetition maximum.

training. Unlike previous research studies, which assessed blood samples immediately after exercise, the authors aimed to examine the long-term effects of training in this study. Therefore, blood samples were taken when the participants were at rest, without having done any warm-up or training. All samples were taken at the same time of the day, both before and after the training, to avoid any diurnal confounding. Blood was collected in a 4-mL vacutainer tube, and the extracted serum was stored at -20°C until assayed. FT and C concentrations were determined in triplicate using Cayman's enzyme-linked immunosorbent assay kits (Cayman Chemical, Ann Arbor, Michigan), and the sensitivity for T and C was reported to be approximately 80% B/B⁰.

Leg Power. We assessed leg power using the CMJ test, which is a reliable test to measure the lower limb power in soccer players (intraclass correlation coefficient = 0.97).²¹

The test was taken after a 15-minute warm-up in 3 trials. The jump height was estimated with the help of a wall-mounted chart, marked with lines 1 cm apart. The best of the 3 trials was used for analysis.

Speed. The 20-m single sprint is a standard test for assessing a soccer player's running speed.²² After warm-up, participants ran three 20-m sprints. They were given full recovery time before the next run. The sprints began with the participants in a forward lunge position. The elapsed time was measured by 2 timekeepers using a hand stopwatch accurate to 0.1 seconds. If the clocked time showed a difference of more than 0.2 seconds, the trial was repeated to increase the reliability of the test.

Agility. Agility was assessed using T-test.²³ This test was performed with rest of 30 minutes after speed test, with further

Table 2. Comparison of Demographics and Outcome Measures at Baseline for Male Soccer Players

Variables	Complex Mean $\pm$ SD (n = 12)	Contrast Mean $\pm$ SD (n = 12)	Control Mean $\pm$ SD (n = 12)	F Value	P Value
Age (y)	22.00 $\pm$ 2.41	20.83 $\pm$ 2.08	21.50 $\pm$ 1.83	.91	.41
Height (cm)	173.38 $\pm$ 5.34	171.13 $\pm$ 5.95	171.15 $\pm$ 4.75	.69	.51
Weight (kg)	69.30 $\pm$ 5.15	64.9 $\pm$ 8.47	65.04 $\pm$ 6.15	1.65	.21
BMI (kg/m ²)	22.95 $\pm$ 1.76	22.05 $\pm$ 2.03	22.27 $\pm$ 1.44	.86	.43
CMJ height (cm)	46.98 $\pm$ 4.84	41.95 $\pm$ 4.67	43.97 $\pm$ 6.92	2.48	.10
T-test (s)	11.72 $\pm$ 1.11	12.12 $\pm$ 0.59	11.60 $\pm$ 1.01	1.05	.36
20-m sprint (s)	3.48 $\pm$ 0.35	3.34 $\pm$ 0.12	3.40 $\pm$ 0.26	.87	.43
Cortisol (μ g/dL)	10.07 $\pm$ 4.82	10.90 $\pm$ 5.43	9.09 $\pm$ 2.42	.50	.61
Free testosterone (pg/mL)	18.64 $\pm$ 6.58	18.03 $\pm$ 4.11	18.67 $\pm$ 6.67	.05	.96

BMI, body mass index; CMJ, countermovement jump.

warm-up consisting of low-intensity running. The best of the 3 trials was used for analysis.

Sample Size Calculation

The number of participants was determined using G*Power (version 3.15) (Franz Faul, Universitat Kiel, Kiel, Germany), using data of changes in sprint from the study done by Alves et al,²⁴ who examined the effect of complex and contrast training on the participants. Thirty-six participants (including dropout of 20%) were shown to be necessary based on the effect size of 0.81, α level of 0.05, and power (1- β) of 0.95.

Statistical Analysis

Normality of the data was assessed with Shapiro–Wilk test. All data were found to be normally distributed. One-way analysis of variance (ANOVA) was applied to demographic characteristics and baseline criterion measures between the 3 groups (complex, contrast, and control). To test the effect of intervention after 6 weeks, 3 (complex, contrast, and control group) $\times$ 2 (before and after training), mixed ANOVA was used for all variables to determine the main effect (group effect and time effect) and group–time interaction. When the group effect was significant, Bonferroni test was used for a post hoc analysis to locate the points having a significant difference. The significance level was set at $P < .05$, and confidence interval was 95%.

RESULTS

Participant characteristics are provided in Table 2. Baseline measures of participants showed no significant

differences between the groups (Table 2). Mean $\pm$ SD of dependent parameters before and after intervention is reported for each group in Table 3.

Mixed ANOVA revealed a significant difference in the time effect ($P \leq .05$), whereas a nonsignificant difference was found in the group effect for all outcome variables (Table 3). Group–time interaction was significant for all variables ($P < .01$) except cortisol ($P = .27$; Table 3). The complex group (8.1%) and contrast group (7.7%) showed improvement in CMJ when compared with the control group (0.86%); similarly, there was an increase in FT concentration in the complex training group (28%) and contrast training group (17%). Cortisol concentration decreased similarly in both training groups compared with the control group.

DISCUSSION

The present study was conducted specifically to evaluate the chronic endocrine response to interventional complex and contrast modes of training and to compare their effects on leg power, speed, agility, and FT and C concentrations. The results of the study revealed enhanced sports-specific physical performance with positive changes in the hormonal status after both complex and contrast modes of training. However, the complex mode was found to be slightly superior to contrast training.

Hormonal responses were consistent, with a favorable anabolic milieu after both training protocols. The increase in FT concentrations was recorded to be higher after complex (28%) training than after contrast (17%) training (Table 3). These findings are in line with the work published by Beaven et al²⁵ on complex training, who reported that strength–power (complex) bout produced the

Table 3. Results (Mean $\pm$ SD) of Intervention Groups (Complex and Contrast) and Control Group Before and After 6 Weeks Using 3×2 Mixed Analysis of Variance

Variables	Complex	Contrast	Control	Time Effect (P Value)	Group Effect (P Value)	Time $\times$ Group Interaction (P Value)
CMJ height				<.001	.053	<.001
Pretest	46.98 $\pm$ 4.84	41.95 $\pm$ 4.67	43.97 $\pm$ 6.92			
Posttest	50.75 $\pm$ 4.91	45.16 $\pm$ 4.77	44.35 $\pm$ 6.92			
T-test (s)				<.001	.344	<.001
Pretest	11.72 $\pm$ 1.11	12.12 $\pm$ 0.59	11.60 $\pm$ 1.01			
Posttest	11.15 $\pm$ 0.94	11.85 $\pm$ 0.56	11.73 $\pm$ 1.16			
20-m sprint (s)				.014	.184	<.001
Pretest	3.48 $\pm$ 0.35	3.34 $\pm$ 0.12	3.40 $\pm$ 0.26			
Posttest	3.23 $\pm$ 0.26	3.24 $\pm$ 0.13	3.54 $\pm$ 0.27			
Cortisol (μ g/dL)				.034	.825	.277
Pretest	10.07 $\pm$ 4.82	10.90 $\pm$ 5.43	9.09 $\pm$ 2.42			
Posttest	8.61 $\pm$ 4.5	9.23 $\pm$ 4.43	9.13 $\pm$ 2.43			
Free Testosterone (pg/mL)				<.001	.751	<.001
Pretest	18.64 $\pm$ 6.58	18.03 $\pm$ 4.11	18.67 $\pm$ 6.67			
Posttest	22.55 $\pm$ 5.20	21.10 $\pm$ 4.18	19.09 $\pm$ 6.60			

CMJ, countermovement jump.

greatest increase in the T concentration when compared with other bouts over 4 weeks. Another study also stated that the hypertrophy-type (contrast) protocol increased serum total T by up to 11.3%.²⁶ Contrary to the results of the present study, Kraemer et al¹⁹ reported a decrease in total serum T after the hypertrophy-type protocol. Literature shows that in resistance-trained men, the total serum T concentration increases up to 28% in response to maximal strength-type exercise ($4 \times 10\%$ to 70% 1 RM).¹⁹ In addition, there is a positive correlation between individual changes in FT and maximal isometric force found after 24 weeks of progressive strength training, which emphasized the “importance of biologically active FT for trainability.”²⁷ Indeed, Kraemer et al⁶ noted that differences in exercise-induced hormonal patterns seemed to affect the ability of training men to elicit a hypertrophic response.

Although the mechanisms involved in the increase in resting T after exercise training are not clear, researchers have suggested multiple possible mechanisms. These mechanisms include a stimulation of T secretion by increasing luteinizing hormone production, promoting dilatation of vessels, and increased blood flow in the testes¹ and increasing lactate accumulation, which has a direct stimulatory effect on T secretion.²⁸ In addition, the

increase in FT might be related to changes in the binding affinity of the carrier protein because of a change in pH and temperature owing to exercise.²⁹ The decreased level and uptake of the carrier protein to hormones increases the concentration of unbinding hormones in the blood, and FT concentration is found to be high.²⁹ In addition, long-term adaptations to strength training apparently occur at the level of cellular androgen receptors present on the muscle cells, which seem to increase in number in response to this type of training.³⁰ This adaptation might result in improved hormone–receptor interaction.^{30,31}

On the other hand, the present study found a decrease in C concentration by 11% and 10% in the complex and contrast groups, respectively, showing similar trends to the studies that examined acute responses. Beaven et al²⁶ reported a significant acute C decrease (44.3%) in response to RE-type protocol. Similarly, Smilios et al recorded a 22% drop in serum C after the strength-endurance protocol, which consisted of 15 repetitions performed at 60% 1 RM.³² However, other authors have reported no significant serum C change immediately after exercise in trained men because of maximal strength-type protocols.³³ At present, the possible reason for decrease in C concentration could be from the homeostasis modulation induced by the hypothalamic–pituitary–adrenal axis³⁴ or

owing to alteration in the lactate threshold, as anaerobic training over a long period increases lactate threshold. During the most stressful phases of training, the changes in serum T-to-C ratios seem to be highly individual and might correlate with changes in muscular strength,²⁷ which means that continuous intensive resistance training might lead to changes in the concentrations of serum C and T; however, this requires further investigation.

The present study recorded an improvement of 7% and 3.09% in sprint time and significant improvements in agility time, with a reduction of 0.57 (4.86%) and 0.27 seconds (2.22%) in the complex and contrast groups, respectively (Table 3). Alves et al²⁴ found improvements in 5-m (9.17% in complex training and 7.03% in contrast training) and 15-m sprints (6.19% in complex training and 3.11% in contrast training) after 6 weeks, but failed to record significant changes in the 505-Agility Test in young soccer players.²⁴ However, García-Pinillos et al³⁵ studied a 12-week contrast training program on participants with similar characteristics as those who were studied by Alves et al²⁴ and found significant improvements in Balsom agility test time (5.13%) and a decrease in 5-, 10-, 20-, and 30 m sprint times. In addition, Kotzamanidis et al³⁶ identified a reduction in time equal to 0.15 seconds (3.45%) for a 30-m sprint in soccer players after 9 weeks of combined resistance and speed training. Thomas et al³⁷ found no change in sprint speed but found improvement in the agility after plyometric exercise. Vácsi et al³⁸ also found slight but significant improvements both in the T test (2.5%) and in the Illinois Agility Test (1.7%) after 6 weeks of plyometric training. Statistically significant enhancement was also observed in the CMJ test result in both complex (8.02%) and contrast (7.65%) training groups (Table 3), which is consistent with the previous studies. Talpey et al³⁹ and García-Pinillos et al³⁵ reported the same after 9 and 12 weeks of contrast and complex training, respectively. Vácsi et al³⁸ also found significant improvements in jump height after 6 weeks of power training.

Results of this study indicate an improvement in the explosive force and power, which implies neurologic adaptations to the training program,⁸ and this adaptation improves speed over distances between 5 and 30 m.^{24,35,36,39} Moreover, another rationale behind the training adaptability is the “size principle,” according to which the use of a heavy load is required to activate all motor units and which probably helps in achieving the greatest neuromuscular activation. Although we found a low improvement in agility, perhaps because of a lack of agility-specific drills that agility tests demanded in the training program (eg, changes of direction, breaking, start movements) and a relatively smaller magnitude of improvement in sprint performance, it might be the result of the majority of exercises in training being performed in a vertical plane bilaterally, whereas sprinting is unilaterally performed in the horizontal plane. This lack of postural specificity should be considered for sport-specific movements and training exercises.³⁹ However, the results of the

present study demonstrate that the tension developed over 6 weeks was probably sufficient to stimulate and adapt the neuromuscular function in the athletes and capitalize on the PAP response that enhanced their jump performance. Complex training showed greater improvements than contrast training did (mean percentage is higher), which might be a result of neural adaptations owing to plyometric exercise.³⁷ Neural adaptation was composed of increased neural drive to agonist muscles, changes in muscle activation strategies (improved inter muscular coordination), or changes in mechanical characteristics of the muscle-tendon complex.^{20,38} These neurophysiologic changes together might improve the ability to store and release elastic energy during the stretch-shortening cycle, which improves physical ability of athletes.^{24,36,38,40}

Increase in FT and decrease in C concentrations indicate the positive relationship between exercise and steroid hormonal response, which have important practical implications for fitness trainers, sports scientists, and strength and conditioning coaches in structuring or designing a workout protocol for maximal gains. The findings of the present study suggest that preconditioning with a complex training regimen could possibly be considered in an aim to improve performance in soccer players.

Limitations

This study investigated 1 group of athletes in 1 sport and of 1 sex; therefore, these findings might be limited and not necessarily applicable to other sports, in other regions, or for female athletes. Additional studies would need to be done in those areas to assess whether the outcomes would be similar. Our investigation did not directly measure neurophysiologic variables or changes in muscle fiber type modifying the physical performance in the athletes. Moreover, hormones like insulin or growth hormone should also be measured because they are sensitive to exercise.⁴¹ Therefore, future studies can incorporate these hormones and neurophysiologic or muscular changes. In addition, the effect of confounding variables such as diet, sleep, or motivation on the outcome variables should be addressed in the upcoming studies for better understanding of the results. Psychological behavior (stress, anxiety, or sleep quality) should also be evaluated by future researchers because these factors influence the hormonal responses. Furthermore, the effects of complex or contrast training for the upper extremities and different sports populations (eg, basketball, volleyball, tennis, rugby, hockey) can be studied, too.

CONCLUSION

For this group of soccer players studied, preconditioning effects of both complex and contrast training improved the physical performance and hormonal responses. Complex

training enhanced the ability of soccer players in terms of their agility, speed, countermovement jump, and free T more than contrast training did. However, no difference was observed in the cortisol level after 6 weeks training.

FUNDING SOURCES AND CONFLICTS OF INTEREST

No funding sources or conflicts of interest were reported for this study.

CONTRIBUTORSHIP INFORMATION

Concept development (provided idea for the research): K.A.

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Practical Applications

- Combining 2 different exercise modalities in a session improved the athletic performance and influenced the endocrine system positively.
- Adding strength exercise with the power training session enhanced the ability of the athletes compared with strength exercise alone.

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