MUSCLE STRENGTH, SERUM BASAL LEVELS OF TESTOSTERONE AND UREA IN SOCCER ATHLETES SUBMITTED TO NON-LINEAR PERIODIZATION PROGRAM

REVIEW ARTICLE

Nelson Pacobahyba[1]
Rodrigo Gomes de Souza Vale[1]
Sandro Legey P. de Souza[1]
Roberto Simão[2]
Edil Santos[2]
Estélio Henrique Martin Dantas.[3]

1. Laboratory of Biosciences of Human Motricity(LABIMH – UCB/RJ).
2. Federal University of Rio de Janeiro.
3. Laboratory of biosciences of Human Motricity (LABIMH – UCB/RJ). Strictu Sensu Post-Graduation Program of Castelo Branco University.

Mailing address:
Avenida dos Pescadores, 623, casa 23
28922-175 – Cabo Frio, RJ, Brasil.
E-mail: nelsonpacobahyba@yahoo.com.br

ABSTRACT

The aim of this study is to evaluate the muscle strength and basal serum testosterone and urea levels in soccer athletes. Twenty-four soccer players in pre-competitive period had a blood sample collected to have testosterone and urea concentrations analyzed. Subsequently, 1RM tests were applied to the bench press and squat exercises. After data collection, the athletes were randomly divided in two groups submitted to: non-linear periodization program (G1) and non-periodized program (G2), both for 12 weeks. ANOVA for repeated measures showed increase in serum testosterone concentration in G1 ($\Delta = 3.70$ ng/dl; $p = 0.0001$) and in G2 ($\Delta = 1.81$ ng/dl; $p = 0.035$) and reduction in urea levels only in G1 ($\Delta = -3.08$mg%; $p = 0.0001$). G1 presented higher levels of testosterone ($\Delta = 2.13$ ng/dl; $p = 0.009$) and lower levels of urea ($\Delta = -1.36$mg%; $p = 0.026$) in the post-test when compared to G2. 1RM tests did not show significant differences. The non-linear training in soccer players was more effective than the non-periodized training in promoting increase in serum testosterone levels and reduction in urea levels.

Keywords: hormones, physical education and training, soccer.

INTRODUCTION

In soccer, strength is associated with high-intensity functional performance. Fast alterations in direction and dislocation velocity are frequent demands in soccer matches and they are crucial for marking, dribbling and game tactics[1]. These demands may be influenced by human and athletic performance, being dependent on muscle strength and power. Thus,the acknowledgment on the muscle strength levels contributes to the prescription of rehabilitation exercises as well as to the development of athletic properties[2].

Strength increase is associated with better neural coordination, as well as increase in the area of transversal section of the muscle. Increase in muscle mass depends on protein synthesis, being it influenced by the endogenous responses of the many anabolic hormones, among which, we highlight testosterone[3].

This hormone is necessary for maintenance of muscular mass and anabolism in humans, although it occurs by ways somehow not very clear yet, but it is important for the structure and function of the skeletal muscle[4]. Kuoring*et al.*[5] observed increase of isometric strength and muscular mass of lower limbs, corroborating the interaction between endogenous testosteroneand androgenic receptors (AR) in the recovery phase, with consequent increase of protein synthesis, muscular hypertrophy and strength.

Contrary to the testosterone, cortisol, a hormone of catabolic characteristics for its hyperglycemiant function, increases the protein degradation rate, being expressed by the urea levels[6]. It is defined as adiamide, which begins its cycle in the liver mitochondria, but builds the three subsequent steps in the cytosol and results from the breakdown of the proteins to their basic units which are the amino acids. Urea circulates in the blood, and is later excreted in the urine[7].

Blood urea concentration depends on physical exercises, which, on their turn, have muscular strength as an important component.The combination of the number of repetitions, sets and overload are the strength training components, although it is not clear yet which is the best combination of the mentioned variables for a better response[8].

Strength training in bodybuilding is well-spread as a sports training instrument and it can be periodizedor not. The non-periodized training is characterized by themaintenance of volume and intensity. The periodized or training, which is subdivided in linear or non-linear, presents alternance between volume and intensity. Linear periodization, also known as classic, may suffer constant inverse alterations of training intensity and volume during the preparatory period; however, it always has specific manifestation of strength as goal. Non-linear periodization is characterized by constant alteration of volume and intensity in the different strength training sessions[9].

Non-linear periodization has been applied to supply deficiency in the calendar of sports modalities such as soccer, in which the teams are made to play twice a week for up to 10 months and a half per year[10]. Due to this requirement, this periodization model works with all strength manifestations which are necessary in this modality.

Thus, the aim of the present study was to evaluate muscle strength and basal serum levels of testosterone and urea in soccer athletes submitted to non-linear periodization program and non-periodized program.

MATERIAL AND METHODS

Sample

All the 24 athletes of the filed soccer team of the Cabofriense Sports Association, from the under-20 category participarted in this research. The subjects should be in full sports activity, free from osteomyoarticular injuries or any other disease which limited the exercise practice. They were randomly divided in two groups: group 1 (G1), composed of 12 subjects (body mass: 64.7 ± 6.6kg, height: 172.3 ± 5.9cm, fat %: 5.2 ± 2.8, age: 17.5 ± 1.0 years) who were submitted to 12 weeks of strength training with non-linear periodization and group 2 (G2), composed of 12 subjects (body mass: 66.1 ± 4.8, height: 177.2 ± 6.1cm, fat %: 5.1 ± 1.2, age: 17.7 ± 0.5 years) who were submitted to 12 weeks of non-periodized strength training.

All procedures used in this study were approved by the Ethics in Research Committee of the Castelo Branco University (protocol # 0091/2008) and the subjects signed the Free and Clarified Consent Form according to the Declaration of Helsinki[11].

DATA COLLECTION PROCEDURE

Anthropometric evaluation

Bod mass and height were evaluated with a mechanical scale of 150kg capacity and 100g precision with Filizola (Brazil) stadiometer. The *International Society for the Advancement of Kinanthropometry protocol* was used for both[12]. The fat percentage (fat%) was evaluated through the seven skinfolds protocol with use of a Lange (Switzerland) scientific adipometer with 1mm resolution[13].

Blood collection

Blood was collected after 12-hour fast, in the morning shift, comprised between eight and 11 hours, to evaluate the serum testosterone. Approximate 0.2ml of sterile saline solution was needed to double determine it. The analysis procedures followed these steps: about 4-5ml of blood was collected in test tube labeled accordingly and the coagulation was stored. The blood was centrifuged and the serum was carefully removed. It was stored at 4ºC for up to 24 hours at minus 10ºC or less if the test was later performed. The *KIT ELISA Diagnostic Biochen Canadá Inc. Direct Testosterone*,1973 was used, while for urea analysis, serum, plasma with EDTA was collected Such kit has been used as determination method of the urease activity and storage temperature was kept at 2 to 8ºC.

Streng the valuation

Strength evaluation was performed by the application of the one repetition maximum test (1RM), following the Baechle protocol[14]. All the tested subjects had minimum experience of 12 weeks in strength training and were accordingly told about the evaluation procedures they were submitted to. Strength evaluation was thoroughly performed by the same evaluator whose reliability was randomly tested with 10 subjects one week before the experiment, with interval of 72h between tests, presenting an intraclass correlation coefficient (ICC) of 0.93.

Each subject was told to perform a movement with motor gesture performed in the test, which comprised: bench press – individual at dorsal decubitus, feet on the ground, elbows extended, hands supinated holding the bar with lateral distance of 20cm to the line of each shoulder, performed on a bench specific to this exercise with bar support brand name Righetto (Brazil). The movement consisted in elbows flexion until the bar slightly touched the thorax in the direction of the nipples and total extension for elbows was done; squat – individuals at standing position, feet with small abduction and bar rested close to the cervical region and Biotech (Brazil) squat bars were used. The movement consisted in flexing knees up to 90º and returning to total extension.

In both movements no alterations in anatomic positions were allowed to avoid the test reliability was compromised. Three-minute interval was given before the first trial, and a single repetition was performed in each trial. A five-minute interval was given between each performed trial or not. Lighter load was placed whenever a trial was not performed.

Intervention

The G1 subjects were submitted to strength non-linear periodization, with three times per week frequency during 12 weeks. They performed 4-6RM, 8-10RM, 12-15RM on the first, second and third days of each intervention week, respectively. The following exercises were used in the intervention: *hackmachine*, seated knee extension, knee flexion machine, seated adduction, ankle flexion, military shoulder press, front pull up, bench press, hip flexion in machine and abdominal crunches. During intervention, Righetto machines were used (Righetto Fitness Equipment; Rua Itacuruça, 568, Jardim Aeroporto, Campinas, Brazil). G2 suffered non-periodized training intervention in which 3x10RM were performed three times per week, keeping volume and intensity unchanged, using the same exercises described for G1.

STATISTICAL ANALYSIS

Data were treated with the statistical package SPSS 14.0 and presented as mean and standard deviation. Data normality and homogeneity variance were analyzed by the Shapiro-Wilk and Levene tests, respectively. Analysis of variance (ANOVA) for repeated measures was used, where the first factor was the groups (G1 and G2) and the second factor the repeated measures (pre and post-test), followed by Tukey *post hoc* to identify the possible differences. The adopted value for statistical ignificance was $p < 0.05$.

RESULTS

Figure 1 presents the results of the testosterone analysis in the pre and post-intervention phases. Significance increase in G1(Δ = 3.70ng/dl; $p = 0.0001$) and in G2 (Δ = 3.70ng/dl; $p = 0.0001$) was observed in the intragroup comparisons. In the post-test, G1, which was submitted to strength non-linear periodization, presented testosterone levels higher than G2 (Δ = 2.13ng/dl; $p = 0.009$).

Figure 2 presents the results of the urea analysis in the pre and post-intervention phases, where significant intra and intergroup differences have been observed. In the presented results, significant decrease in the urea levels was verified only in G1 (Δ = –3.08mg%; $p = 0.0001$) after strength non-linear periodization intervention. G2 did not obtain alterations. In the post-test, G1 presented lower urea levels than G2 (Δ = –1.36mg%; $p=0.026$).

Figure 3 presents the results of the 1RM test in the squat and bench press exercises from G1 and G2. There were no significant differences in the intra and intergroup comparisons.

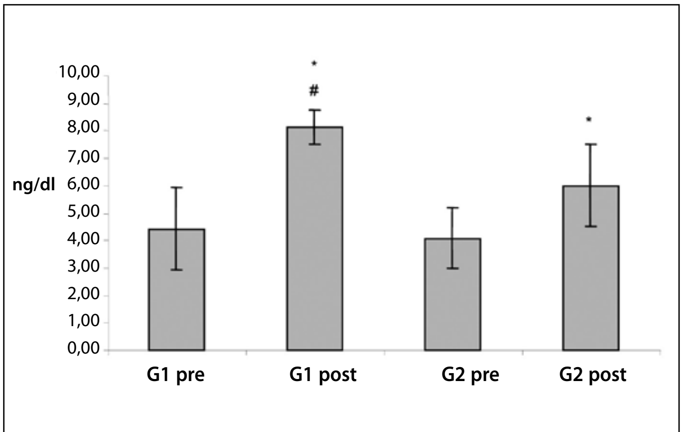

Figure 1. Comparative analysis of testosterone of the groups submitted to non-linear periodization program (G1) and non-periodized program (G2).
* p<0.05; pre *vs.* post.
\# p<0.05; G1 post *vs.* G2 post.

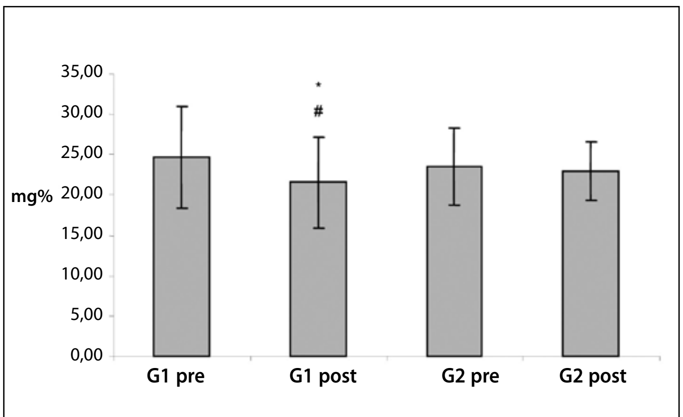

Figure 2. Comparative analysis of urea of the groups submitted to non-linear periodization program (G1) and non-periodized program (G2).
* p<0.05; pre *vs.* post.
\# p<0.05; G1 post *vs.* G2 post.

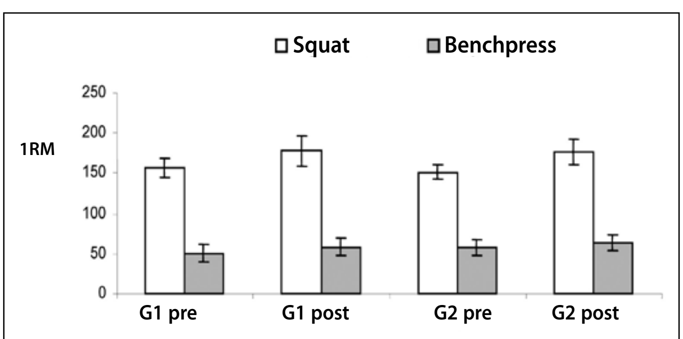

Figura 3. Comparative analysis of the 1RM test for squat and bench press in pre and post-test in G1 submitted to strength non-linear periodization and G2 submitted to non-periodized strength training.

DISCUSSION

G1 was submitted to strength non-linear periodization for 12 weeks and presented higher testosterone serum level when compared with G2, which underwent the non-periodized intervention. This finding is confirmed in the study by Edwards *et al.*[15], which presents significant statistical difference for total and free in the plasma testosterone increase after physical exercise in soccer players, attributed to the volume and/or intensity proportionality associated to reduction of metabolic left overs, hemo concentration as well as secretion increase.

The results of the present study are corroborated by Nebigh *et al.*[16], with university soccer players submitted to physical training during puberty, which found increase in the testosterone level in these subjects when compared with the control group of non--practitioners. They justified the increase of body lean mass obtained by the indirect testosterone action on the growth hormone (GH). However, the present study did not evaluate the development of muscle mass, a fact which limits these considerations. Nevertheless, in both studies the subjects submitted to physical training presented increase in the testosterone levels.

Contrary to testosterone, reduction in the blood urea levels in G1 was observed, suggesting hence lower ammonia concentration, which could be high during physical exercises by the increase of deamination of amino acids.This metabolite contributes in a negative way to the metabolic harm of muscles and the brain, consequently causing peripheral and central fatigue[17].

The result obtained by the present study referring to the analysis of nitrogen residue, done through the urea metabolite, presented expressive intra and intergroup reduction in the serum urea levels in G1. Such fact demonstrates result with lower concentration of this metabolite in the use of strength non-linear periodization during 12 weeks. Such result expresses lower depletion of muscular proteins, since, according to Cunha *et al.*[18], the nitrogen residue concentration in the plasma is an indication of fractioning of muscular proteins caused by consequent increase of the catabolic state.

The strength non-liner periodization to which G1 was submitted in this research was also used by *Uchidaet al.*[19]with strength training practitioners and application of multiple sets. They find reduction of catabolic hormone, cortisol and consequent reduction of the urea serum levels. This episode can favorably signal the protein anabolism by strength training practice, corroborating hence the findings of the present investigation.

The results found in the 1RM pre and post-tests for the squat and bench press exercises in G1 and G2 did not show significant differences in strength gain. It can be attributed to the experience in strength training of the subjects involved in the research, which reduces the neural modulation of the tested subjects, as well as the 12-week period reserved to the intervention not being sufficient for effective strength gain. These results are supported by the finding by Simão *et al.*[20], who state the importance of the hypertrophic factor in the composition of the sample with trained individuals, affirming that 12 weeks of intervention are not sufficient to develop strength with individuals with physical characteristic with great muscle development.

In a position adopted by the *American College of Sports Medicine* (ACSM)[21], subjects in high training stage should present delayed results in the differences obtained in strength gain in one set or multiple sets. Periods which range from four to 25 weeks have not shown to be sufficient to significantly alter strength. Thus, the strength results presented in this research are in agreement with the ACSM, since G1 and G2 were submitted to 12 weeks of intervention.

The findings in strength of 1RM in G1 and G2 may be related to the fact that the subjects involved in both groups presented high performance in sprint running due to the soccer practice. This relation is reported by Fleck and Kraemer[22]in research with athletes, showing that the metabolic system used for the strength training is the same for sprints. Thus, it can be concluded that the subjects trained in short distance velocity present better results in the 1RM tests, justifying the results in G1 and G2.

CONCLUSION

The results of this study evidenced that non-linear periodization strength training for soccer players was more efficient than the non-periodized training in promoting increase of the serum testosterone and reduction of the urea levels. However, the results obtained for muscle strength were not different between the training models and deserve future investigation which uses longer intervention time and subjects from other soccer categories.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Hespanhol JE. Mudanças no desempenho da força explosiva após oito semanas de preparação com futebolistas sub-20. Rev Movimento e Percepção2006;6:82-94.
2. Brown LE, Weir JP. Accurate assessment of musculaar strength and power.JEPonline 2001;4:11-21.
3. Hansen L, Bangsbo J, Twik J, Klausen K. Development of muscle strength in relation to training level and testosterone in young male soccer players. J ApplPhysiol 1999;1141-7.
4. AxxelA-M, Maclean H, Plant DR, Hardcourt LJ, Davis JA, Jimenez M, et al.Continuous testosterone administration prevents skeletal muscle atrophy and enchancesresistence to fatigue in orchidectomized male mice. Am J PhysiolEndocrinolMetab 2006;291:E506-16.
5. Kuoring T, Andersen M, Brixen K, Madsen K.Suppression of endogenous testosterone attenuates the response to strength training: a randomized, placebo-controlled, and blinded intervention study. Am J PhysiolEndocrinolMetab 2006;291:E1325-32.
6. França SCA, Barros Neto TL, Agresta MC, Lotufo RF, Kater C. Resposta divergente da testosterona e do cortisol séricos em atletas masculinos após uma corrida de maratona. Arq Bras EndocrinolMetab 2006;50:1082-7.
7. Nelson David L, Cox Michael M. Leningherpriciples of biochemistry. 4ªedicão. New York:W. H. Freeman and Co 2004
8. Silva NL, Frinatti PTV, Influência de variáveis do treinamento contra resistência sobre a força muscular de idosos: uma revisão sistemática com ênfase nas relações dose-resposta.Rev Bras Med Esporte 2007;13:60-6.
9. Fleck SJ, Strength training in explosive-type sports: sprinting. 5thInternationalConferenceonStrength Training, Oktober, 2006.
10. Dantas Estélio HM, A prática da preparação física. 5ª.edição. Rio de Janeiro: Shape, 2003
11. World Medical Association (WMA),Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. 59th WMA General Assembly, Seoul, 2008.
12. Marfell-Jones M, Olds T, Stewart A, Carter L, International standards for anthropometric assessment. ISAK: Potchefstroom, South Africa, 2006.
13. Jackson AS, Pollock ML, Generalized equations for prediting body density of men.Br J Nutr ;40:497-504.
14. Beachle TR, Earle RW. Essentials of strength training and conditioning.Champaign: Human Kinetics, 2000.
15. Edwards DA, Wetzel K, Wyner DR. Intercollegiate soccer: saliva cortisol and testosterone are elevated during competition, and testosterone is related to status and social connectedness with teammates. PhysiolBehav 2006;87:135-43.
16. Nebigh A, Rebai H, Elloumi M, Bahlous A, Zouch M, Zouali M, et al. Bone mineral density of young boy soccer players at different pubertal stages: relationships with hormonal concentration. Joint Bone Spine 2009;76:63-9.
17. Nybo L, Dalsgaard MK, Steenberg A, Moller K, Secher NH.Cerebral ammonia uptake and accumulation during prolonged exercise in humans.J Physio2005;563:285-90.
18. Cunha GS, Ribeiro JL, OliveiraAR.Teoria, diagnóstico e marcadores. RevBrasMed Esporte 2006;12:277-95.
19. Uchida MC, Bacurau RFP, Navarro F, Pontes Junior FL, Tessuti VD, Moreau RL.Alterações da relação testosterona: cortisol induzida pelo treinamento de força em mulheres. RevBrasMed Esporte 2004;10:165-8.
20. Simão R, Fonseca T, Miranda F, Lemos A, Polito M.Comparação entre séries múltiplas nos ganhos de força em um mesmo volume e intensidade de treinamento. Fit Perf J 2007;6:362-6.
21. Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Fleck SJ.Progression Models in Resistance Training for Healthy Adults.American College of Sports and Medicine, ACSM Position Stand.MedSci Sports Exerc2009;31:364-80.
22. Fleck SJ, Kraemer WJ. Fundamentos do Treinamento de Força Muscular. 3. Ed, Porto Alegre: Editora Artmed, 2006.

ERRATUM

In the RBME, volume 16, issue 6, November/December,2010, in the article "Muscular overload training does not affect the diameter of the main veins of the lower limbs in adult women with venous insufficiency", tables 3 and 4, on pages 415 and 416, respectively, should be substituted for the following tables 3 and 4:

Table 3. Diameters of the great saphenous vein at thigh level in the pre and post-training moments.

Variable/test	EG[a] (n = 10)	CG[b] (n = 10)	Effects	F	P
VSMC[c] superior			ANOVA		
Pre- training	4.08 ± 1.55	3.69 ± 0.90	Group	0.47	0.49
Post-training	3.90 ± 1.68	3.53 ± 1.28	Training	0.75	0.39
Δ%	-4.61	-4.53	*Training group	0.00	0.97
Mean VSMC			ANOVA		
Pre-training	3.13 ± 0.95	3.51 ± 1.03	Group	0.31	0.57
Post-training	3.05 ± 1.05	3.15 ± 1.14	Training	2.24	0.14
Δ%	-2.62	-11.42	*Training group	0.87	0.36
Lower VSMC			ANOVA		
Pre- training	3.13 ± 1.00	3.37 ± 0.93	Group	0.42	0.52
Post-training	2.96 ± 1.11	3.28 ± 1.23	Training	0.50	0.48
Δ%	-5.74	-2.74	*Training group	0.45	0.83

a: experimental group; b: control group; c: great saphenous vein at thigh level.

Table 4. Diameters of the small saphenous vein in the pre and post-training moments.

Variablel/test	EG[a] (n = 10)	CG[b] (n = 10)	Effects	F	P
Upper SSV[c]			ANOVA		
Pre- training	2.55 ± 0.71	2.45 ± 0.62	Group	0.23	0.63
Post-training	2.59 ± 0.97	2.39 ± 0.65	Training	0.00	0.93
Δ%	+1.54	-2.51	*Training group	0.22	0.63
Mean SSV			ANOVA		
Pre- training	2.46 ± 0.55	2.51 ± 0.53	Group	0.11	0.74
Post-training	2.30 ± 0.55	2.40 ± 0.55	Training	1.78	0.19
Δ%	-6.95	-4.58	*Training group	0.07	0.78
Lower SSV			ANOVA		
Pre- training	2.25 ± 0.38	2.23 ± 0.54	Group	0.00	0.96
Post-training	2.08 ± 0.57	2.13 ± 0.59	Training	1.65	0.21
Δ%	-8.17	-4.69	*Training group	0.12	0.72

a: experimental group; b: control group; c: small saphenous vein.