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The Effects of Athletics Training on Isometric Strength, EMG Activity and Resistance Training in Male Adolescent Athletes

Abstract

The aim of this study was to evaluate the effect of three different training programs on electromyographic activity (EMG), isometric strength, resistance training and quadriceps hypertrophy in track and field athletes. 27 male adolescents' athletes were divided in three (3) groups of nine (9), the Neuromuscular Group (NeuroGr), the Hypertrophy Group (HyperGr) and the Control Group (ControlG). The participants in both NeuroGr and HyperGr trained 3 times per week for 8 weeks while the athletes of ControlGr did not take any exercise. The maximal isometric strength and muscular hypertrophy of all participants' right thigh were measured pre, in the middle and at post training programs. At the time course of 8 weeks, the ANOVA revealed a significant improvement in isometric strength (21.4%) and hypertrophy (10.3%) in the athletes of NeuroGr. Similarly, the athletes' of HyperGr improved in isometric strength and hypertrophy 18% and 15.5% respectively, while no changes were observed in strength elements of ControlGr athletes. Furthermore, the EMG evaluation showed that the hypertrophy Increase of FlyperGr athletes was a result of both neurophysiological adaptive mechanisms and hypertrophy factors. In athletes of NeuroGr the neuro physiological characteristics prevail while the hypertrophy adaptation contribution was limited. As control group. The following fitness variables were selected for the purpose of the study: Flexibility test (sit and reach test), strength test (vertical jump test), speed test (5 cm dash test), agility (shuttle run test), and cardio-vascular fitness test (cooper 12 minute run-walk test).

Introduction

The relevance of strength in athletic performance varies from one sport to another. Modem training the muscular strength is a dominant factor and also a prerequisite for efficient skill learning and mastery in competitive sports.

Specifically, the strength training has a lot of positive adaptations which, through the musculoskeletal and hormonal systems, leads to the development of strength condition in athletes. As it was mentioned in mid 80's, the maxi-mal muscular strength, which is acquired by the neuromuscular coordination method of training, has a notable Improvement especially through the in-creasing number of activated motor units (10). In addition, the above re- searcher reported that the use of the hypertrophy method leads to the maxi- mal strength gain via the cross-sectional area muscle (size) increase. Furthermore another leading study applied a training program with maxi- mal strength and high resistance loads (70% - 100% of 1 RM, 1 to 10 repetitions for 24 weeks in mature athletes and its findings showed that the strength improvement originates from neuromuscular factors (5). However, the muscle hypertrophy adaptations have a limited contribution to the strength de-development (12). In addition, another study in 11 yr old participants reported that the muscular strength resulted only from neuromuscular and not from hypertrophy adaptations (14). In contrary, other study supported that the maxi-mal strength adaptations in mature males, after an 8-week training program is not related to the development of muscle electrical characteristics but to hypertrophy factors (15).

The aim of the present study was to evaluate the effects 3 of types of maximal strength training programs on quadriceps isometric strength, hypertrophy of adolescent trained athletes resistance training and to identify whether the athletes' strength improvement results from neuromuscular coordination or hypertrophy factors.

Resistance training programme can improve measures of strength and power in adults. In children and adolescents, it is well-established that training-induced gains in strength and power are indeed possible following participation in a resistance training programme. Resistance training during a training cycle should bestructured to allow maximal efficacy and physical improvement. Since youngathletes are often encouraged to perform static stretching prior to resistance exercise. Resistance training has been used extensively to increase fitness and sport performance.

It has been demonstrated to augment maximum strength, power and jumping ability. It is well known that a variety of resistance training programs can stimulate and increase in one repetition maximum strength. It is important to ascertain the most efficacious method for enhancing fitness performance in children and adolescents.

Procedure and Methods

Participants

27 male adolescent athletes from a track and field club were recruited for the study. The athletes were sprinters and jumpers. For the purpose of this study the athletes were randomly divided into three (3) groups of nine (n = 29). Prior to the beginning of the training protocols, oral instructions were given about the nature of the research as well as what the athletes should avoid before and during the testing procedures. The study was performed according to the rules of the Ethics Committee of the Democritus University of Thrace.

Research Design

The athletes who participated in Neuromuscular Group (NeuroGr) exercised with a maximal strength training program using the neuromuscular coordination method (inter and intramuscular coordination and motor synchronization) 3 times per week as well as with a sprint running program 2 times per week in a amount of 8 weeks. Similarly, in the athletes of the Hypertrophy Group (HyperGr) a maximal strength training program was applied 3 times a week using the hypertrophy method (stimulating the muscles enough to gain muscle mass) while their sprint running program was the same as the NeuroGr.

In the contrary, the athletes of the Control Group (ControlGr) did not perform any strength training program but only the sprint running session 2 times a week in a period of 8 weeks, (Table I). The measurements were held just be-fore (pre), in the middle (4th week) as well as at the completion of the training program (8th week).Testing procedures.

The Evaluation Protocol consisted of the Three following Tests:

a) **Right thigh isometric strength:** The evaluation of quadriceps strength was applied by using the isometric dynamometer (ERGO METER GLOBUS TECHNICA ESPORT). The athlete sat in a leg extension machine which was connected to the electrical dynamometer with the knee and hip angles at 120o and 90o respectively (15). Then, the subject's right leg was fastened in the chair from the ankle and hip joints while both hands were let free on the side of the hips. From the above seating position the participants performed 10 maximal leg extensions at a 5s time - frame each, in which the first 7 efforts must have been submaximal while the 3 finals must have been maximal.
b) **Quadriceps Hypertrophy Adaptations:** The Computed Tomography - CT (General Electric Company, 1991) was used in order to measure the geometric area of 3 transverse sections of the rectus femoris, vastus lateralis and vastus medialis (3, 13). The CT scanning analysed the mid - points and the denser part (belly) of the above muscle and they were the same with the points in which the electrode probes were located. The above men-tioned analyses were applied at the pre - training and at the end (8th week) of the training programs.
c) **EMG:** The signals of the EMG were acquired by using 3 pairs of single - use bipolar electrodes at the motor points of rectus femoris, vastus lateralis and vastus medialis of the right thigh (16). For the EMG analysis the Ariel Performance Analysis System - APAS (Inc. USA) device was used. Each electrode was attached parallel to the assigned muscle tissues directions in order to analyze entirely the exercised muscles (1). Then the right leg was fastened aroun4 the lower calf at the isometric chair with the knee and hip angles at 1200 and 900 respectively. From the relaxed leg position and EMG zero aligned signals and from

the first visual stimulus the subject started to perform while the EMG and the isometric muscular contractions were recorded. Ten (10) consecutive efforts were done while the last 3 were maximal in the recording time-frame of 5s. The EMG mean frequency was 1000Hz while the sampling rate recorded from 1-500 Hz. The quantification of EMG patterns was performed as follows: i) full transition of the initial EMG, ii) the mechanical voice removal by using band-pass filters (100 □z), iii) the circular graph estimation (IEMG), and iv) the signal RMS evaluation. The method (12) of concerning the contribution of the neuromuscular and hypertrophy factors for the EMG evaluation was applied.

d) **Resistance Training:** Measurements for variables were taken at the beginning (pretest) and at the end of experimental training period after eight weeks (post-test). The following variables were selected for the purpose of the study: Flexibility Test (Sit and Reach Test, 1952), Strength Test (Vertical Jump Test, 1921) Speed Test (50 m dash test, 1977), Agility (Shuttle Run Test, 198), Cardio-vascular Fitness Test (Cooper 12 minute Run-Walk Test, 1968). Tocompare the mean difference between pre-test and post-test, t-test was computed with the help of SPSSSoftware and level of significance chosen was 0.05.

Statistical Analysis

This research data normality was checked by using the Vander Waerden's method, while the variables' normal distributions were confirmed by the probability P-P plots. The statistical analysis for this study's measured variables was based on the General Linear Model. The interaction among the evaluated variables in each training group (3 3) was assessed by the use of Analysis of Variance with the dependent factor "Measurements" (pretraining, mid & post - training programs) and with the independent factors "Group" (Neuro Gr - HyperGr - ControlGr). The Bonferroni test (post hoc comparison) was applied in order to identify inter "Groups" statistically significant differences in the study's measured variables. The acceptable level of significance was set at 0.05 and all results were reported as mean standard deviation. SPSS statistical software version 17.0 for Windows (SPSS Inc., Chicago, IL, USA), was used for data management and statistical calculations.

For the variables, the statistical analysis revealed a significant differences between the pre-test and post-test of experimental group regarding vertical jump, 50 m dash, shuttle run and cooper 12 mm run walk of man.

There were significant differences found in the fitness level of before and after resistance training.

Results

Quadriceps isometric strength: the results showed a significant interaction among HypciGr, NeuroGr and ControlGr from the 1st to 3rd measurement (F=4.83, p 0.01). Both NeuroGr and HyperGr athletes had a significant improvement in maximal isometric strength from the first to the last evaluation as measured in 21.4% for the NeuroGr and 18% for the HyperGr (p 0.0l). In ControlGr the participants did not present any improvement in maximal iso-metric strength (Figure 1). The post hoc multiple comparisons did not reveal any statistically significant differences in maximal isometric strength between the NeuroGr and HyperGr.

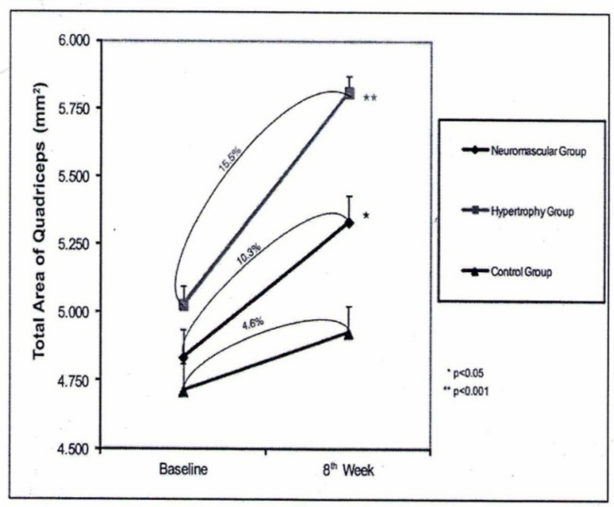

Figure 1. The percentage (%) of improvement in athletes' quadriceps maximal isometric strength of all studied groups pre-training, in the 4th and 8th week measurements. Muscular hypertrophy adaptations: the research findings showed a significant interaction among the HyperGr, NeuroGr and ControlGr from the 1" to 3rd measurement (F = 4.78, p 0.05). All the athletes of NeuroGr and HyperGr significantly improved in quadriceps adaptations strength from the first to last evaluation as measured in 10.3% for the NeuroGr (p 0.05) and 15.5% for the HyperGr (p<0.001). In ControlGr the subjects did not present

any adaptive responses in quadriceps hypertrophy (Figure 2). The Bonferroni comparisons did not reveal any statistically significant differences between the NeuroGr and HyperGr while the athletes ‘of HyperGr tend to have a marginal hypertrophy improvement in relation to the athletes of NeuroGr.

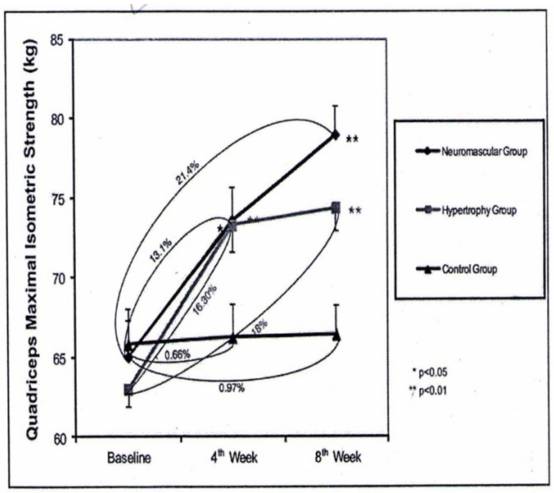

Figure 2. The percentage (%) of quadriceps hypertrophy improvement (sum of the geometric area of rectus femoris, vastus lateralis and vastus medialis) in all groups at the pre-training and 8th week (post - training) measurements. Electromyography (EMG): According to (12) method the percentage of neuromuscular coordination and hypertrophy factors in the strength development were estimated by using the linear graph between the improved strength counting values (including the maximal strength) and the measuring EMG signals. Thus, in this study the linearity of the computed Root Mean Square(RMS) EMG signals and the measured strength values showed that in NeuroGr the 62.5% of isometric strength improvement was related to neurophysiological factors, while the 37.5% of isometric strength improvement resulted from both hypertrophy and neuro physiological elements. It is important to take into account that in the athletes of HyperGr the mean isometric strength improvement was connected to both hypertrophy and neuro physiological factors. In the 50% of the participants in ControlGr, no significant strength improvement was observed in either neuromuscular or hypertrophy adaptations. In the 25% of the ControlGr participants a neuromuscular improvement was ob- served while in the rest 25% of the participants both hypertrophy and neuro- physiological factors were equally improved.

Analysis of data revealed no significant differences between pre test and post test of control group, since the computed values of ‘t’ on sit and reach (.403), vertical jump (.367), 50 m dash (1.22), shuttle run (1.97), cooper 12 minute run walk test (.221).

Conclusion

From this research it was reported that the athletes of NeuroGr and resistance training had a significant improvement both in maximal isometric strength and hypertrophy in the exercised quadriceps. At the athletes of NeuroGr resistance training the interaction between the RMS EMG outputs and the recorded isometric strength showed that quadriceps substantial adaptations are primarily developed through neuro physiological factors and less affected by hypertrophy. From a functional point of view, the above findings are in accordance with recent studies which report that the increase of the maximal isometric strength in athletes was associated with the neural drive improvement of the trained muscle (4, 8). The completion of the training program improved significantly both the maximal isometric strength and quadriceps hypertrophy. The RMS EMG recording at the isometric strength showed that the HyperGr athletes' strength development is the result of both muscle specific neural and hypertrophy adaptations. Similarly, other studies, in which the strength training programs were applied by using submaximal loads, support that the isometric strength and resistance training deve1opment is the result of both neuromuscular and hypertrophy factors. Nevertheless, in studies in which the training program was based on intensity of 90% of 1 - RM with a short number of repetitions, it was reported that the neuromuscular factors were strongly related to the athletes’ maximal strength improvement in relation to hypertrophy factors.

In contrast, other study supports that the strength improvement was related only to neuromuscular factors. Furthermore, a similar to the above study which applied 3 strength training programs of different intensities (S RM, 10 - RM and 20-RM) revealed that all strength programs improved equally the maximal strength as well as the intramuscular coordination in biceps. A possible explanation for the above conflict results, according to be the subjects’ age and training background, the duration as well as the type of strength training programs. In conclusion, this study reports that both neuromuscular and hypertrophy muscles strength training protocols improved the trained athletes' quadriceps isometric strength and resistance training. Furthermore, these two training protocols increase the quadriceps hypertrophy mostly in the adolescent athletes of HyperGr. The strength improvement of the HyperGr is equally based on neuromuscular factors and hypertrophy while in the NeuroGr the strength development mechanisms originated from neurological components with a marginal contribution of hypertrophy.

In experimental group, the training positively affected the fitness level

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