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American College Sports Medicine Strength Training and Responses in Beginners

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ABSTRACT

Asano RY, Levada-Pires AC, Moraes JFVN, Sales MM, Coelho JMO, Neto WB, Neto JB, Tibana RA, Sousa JC, Prestes J, Simões HG, Pithon-Curi TC. American College Sports Medicine Strength Training and Responses in Beginners. **JEPonline** 2012;15(5):1-9. The aim of this study was to investigate the acute physiological effects of three guidelines for muscle hypertrophy, muscle strength, and endurance, as suggested by the American College of Sports Medicine (ACSM). Eleven untrained men performed a random sequence of 3 strength training protocols in accordance with ACSM's standardized strength training guidelines. Blood pressure, heart rate, glucose, lactate, rate of perceived exertion, and creatine kinase activity were investigated before and after training. Our results demonstrate that among the three training protocols recommended by the ACSM for untrained individuals, the hypertrophy protocol produced muscle tissue damage, high lactate concentration, and hypoglycemia. In regards to the physiological responses, only moderate changes were found in all protocols.

Key Words: Resistance Training, Acute Response, Muscle Damage

INTRODUCTION

Strength training (ST) is the most effective method for maintaining or increasing muscle strength (11). It is one of the most practiced types of physical activity in gyms, especially since it is recommended for strength enhancement as well as for the prevention and treatment of degenerative diseases (15). Strength training also alters blood pressure (BP) (23), heart rate (HR) (7), glycemia (GLU) (28), lactate (LAC) (3), and rate of perceived exertion (RPE) (10). Based on individual goals, several variables are generally considered when designing a ST program (e.g., the volume of exercise, sets, recovery intervals, exercise order, speed of execution, and exercise intensity) to augment muscle strength, endurance, and size (6,17).

In 2002 and 2009, the American College of Sports Medicine (ACSM) published guidelines for ST protocols that are commonly used in ST programs for beginner, intermediate, and advanced subjects. While it is understood that the protocols increases size, strength, and endurance of the trained muscles (2,15), the influence of the ST protocols on the acute physiological responses of untrained subjects is less clear. Thus, the purpose of this study was to compare the effects of the different ACSM strength training protocols on BP, GLU, LAC, RPE, and muscle tissue damage in untrained subjects.

METHODS

Subjects

Eleven healthy men (24.5 ± 8 yrs old; 70.4 ± 8.1 kg; 171.2 ± 5.1 cm; 23.9 ± 1.99 kg·m⁻²; $15.3 \pm 3.6\%$ body fat) participated in this study. None of the subjects had a previous history of strength training. Thus, according to ACSM (2), the subjects were considered “untrained” normotensive, non-diabetic, non-athletes who were not engaged in regular physical training during the past 12 months. All subjects signed a consent form agreeing with the procedures carried out in the study. The procedures were carefully explained and all subjects voluntarily agreed to participate. The subjects were advised to refrain from ingesting caffeine and alcohol for 24 hrs before all tests, avoid any strenuous exercise 48 hrs before the experimental sessions, and to maintain their normal daily diet during the study (26).

Procedures

1 Repetition Maximum Test (1RM)

The subjects were familiarized with the exercises before performing the tests. All questions and/or concerns related to the testing and exercise procedures were addressed. The tests were supervised by the same evaluators on separate days with a minimum interval of 48 hrs between test and retest.

The procedures to determine the 1RM load were performed according to the recommendations of Brown and Weir (4). The 1RM test measures the maximal load in which one can perform a single repetition without being able to complete a second one. The number of attempts was limited to five and the maximal load was considered as the one used in the last attempt in which the subject performed one repetition using the technique.

Prior to the 1RM tests, 8 repetitions at 50% of an estimated load equivalent to 1RM were performed as a warm-up. After a 2-min interval, another set of warm-up consisting of 3 repetitions at 70% of the same estimated 1RM was carried out. Finally, the 1RM load was considered as the maximum load in which a subject could execute one repetition without being able to perform a second repetition. Each attempt to estimate the 1RM load was separated by a 5-min interval with a gradual increase or decrease (e.g., 2.5% to 5.0%) in the load until completion of the test.

Experimental Protocol

The ACSM protocols suggest using exercise intensities that correspond to approximately 60% to 70% of 1RM, 8 to 12 repetitions, 1 to 3 sets of each exercise, and a recovery period of 2 to 3 min when the objective is to increase muscular strength in untrained subjects. When the purpose is to enhance muscular hypertrophy, the intensities used are between 70% to 85% of 1RM, 8 to 12 repetitions, and 1 to 3 sets of each exercise followed by 1 to 2 min of recovery. On the other hand, in order to improve muscle endurance, the recommendations are an intensity of 40% to 60% of 1RM, 10 to 15 repetitions, and recovery periods of \geq 1 min (2,15) (Table 1).

Table 1. Strength Training Protocols Recommended by the ACSM.

Protocol	Intensity	Repetitions	Rest Interval	Speed of execution
Hypertrophy	70% of 1RM	10 to 12	1'30"	Slow
Strength	75% of 1RM	6 to 8	2'30"	Moderate
Muscular Endurance	60% of 1RM	15	1'	Moderate

The subjects performed a randomized sequence of the 3 training protocols with a 2-wk interval between each one. The training sessions were constructed according to the recommendations of the ACSM (refer to Table 1). In all protocols, the eccentric and concentric phases of the movement were performed and the large muscle groups were exercised before the small muscles were. The following ST exercises were performed: bench press, fly, lat pull down, horizontal hack squat, leg curl, leg extension, calf press, arm curl, and arm extension.

Data Collecting Procedures

Before the beginning of each protocol and immediately after the execution of the last exercise, the following variables were determined: heart rate (HR) (Polar FS2), systolic blood pressure (SBP) and diastolic blood pressure (DBP) (OMRON digital blood pressure monitor hem – 413 C), rate pressure product (RPP), and mean blood pressure (MBP). In addition, glucose (GLU) (Prestige IG blood glucose monitor), lactate (LAC) (Accusport Accutrend Boehringer Mannheim ®), creatine kinase (CK), and rate of perceived exertion (RPE) (Borg Scale ranging from 1 – 10) were determined. The subjects remained seated for 10 min to measure resting HR, SBP, and DBP.

Blood Sample Collection

Blood was collected from a cubital vein before and after exercise. It was then centrifuged at 4° C, 500 x g for 10 min. Samples were separated and frozen (-70° C) for creatine kinase assay.

Determination of the Creatine Kinase Activity (CK)

Serum CK is an indirect marker of muscle injury. The CK activity was measured according to Oliver (21). Each subject's first session was considered as the value at rest. During the 3 testing days, each subject was provided a standardized meal prepared by a nutritionist.

Statistical Analyses

Normality of the data was tested using the Shapiro-Wilk test. Homogeneity of the sample was tested using Levene's test ($P=0.118$). A one-way analysis of variance (ANOVA) with Fisher's LSD as post hoc was used to statistically compare the acute physiological responses to the ST protocols (strength, hypertrophy, and endurance). The level of significance adopted was established at $P=0.05$.

RESULTS

The results for the HR, SBP, DBP, RPP, and MBP responses are presented in Table 2. Heart rate during the hypertrophy protocol showed significantly higher values when compared to rest and to the endurance and strength protocols. Both the muscular endurance protocol and the strength protocol were higher ($P=0.05$) when compared to the respective resting values.

Table 2. Cardiovascular Responses to ACSM Strength Training Protocols for Beginners.

Protocol	Rest	Strength	Hypertrophy	Muscular Endurance
HR (beats·min ⁻¹)	80.6 ± 6.0	92.0 ± 5.0*	121.1 ± 7.0*†‡	95.0 ± 4.0*
SBP (mmHg)	121.7 ± 3.0	120.6 ± 6.0	127.0 ± 6.0*†‡	118.0 ± 9.0
DBP (mmHg)	81.0 ± 2.0	69.5 ± 6.0*	69.8 ± 3.0*	73.0 ± 5.0*
MBP (mmHg)	94.0 ± 2.0	87.0 ± 6.0	89.0 ± 2.0*	88.0 ± 4.0*
RPP	9721 ± 886	11252 ± 967*	15448 ± 738*†‡	11309 ± 1330*

HR=heart rate; SBP=systolic blood pressure; DBP=diastolic blood pressure; MBP=mean blood pressure; RPP=rate pressure product; * $P=0.05$ to rest; † $P=0.05$ to strength; ‡ $P=0.05$ to muscular endurance.

The values for the hypertrophy protocol were also higher ($P=0.05$) for SBP and RPP when compared to the other two protocols and to its respective value at rest. Although DBP and MBP decreased significantly ($P=0.05$) in all 3 protocols when compared to rest, there were no significant differences between protocols. Glycemia decreased significantly in all three protocols when compared to the resting values ($P=0.05$). In addition, the glucose concentrations decreased significantly ($P=0.05$) immediately after exercise in the hypertrophy protocol when compared to the endurance and the strength protocols (Figure 1). The lactate values increased significantly ($P=0.05$) after exercise in all three protocols when compared to their respective values at rest. Among the protocols tested, hypertrophy showed significantly higher LAC concentrations when compared to endurance and strength protocols ($P=0.05$). After exercise, CK activity was significantly higher in all protocols when compared to the values at rest. The CK values for the hypertrophy protocol were higher when compared to the endurance and the strength protocols ($P=0.05$). In addition, the strength protocol presented higher CK activity when compared to the endurance protocol after exercise ($P=0.05$) (Table 3). The RPE values in the hypertrophy and endurance protocols were significantly higher ($P=0.05$) when compared to the strength protocol.

Table 3. Creatine Kinase and Rate of Perceived Exertion Values in the Three ACSM Strength Training Protocols for Beginners.

Protocol	Rest	Strength	Hypertrophy	Muscular Endurance
CK (μmol/ml)	110.0 ± 26.4	248.0 ± 100.0*†‡	564.0 ± 145.0*†‡	134.0 ± 44.0*
RPE (Borg 1-10)	----	2.1 ± 0.4	2.7 ± 0.4†	3.0 ± 0.4†

CK=creatine kinase; RPE=rate of perceived exertion; * $P=0.05$ to rest; † $P=0.05$ to strength; ‡ $P=0.05$ to muscular endurance.

DISCUSSION

Even though the hypertrophy protocol promoted a higher increase in HR when compared to the other protocols, the percentage of the HR reserve was only 30%. When related to maximal oxygen uptake, the HR reserve reveals a strong association between the percentage values of these variables (13). Therefore, the ACSM muscle hypertrophy protocol was performed at an intensity that is considered as moderate or below the anaerobic threshold (11).

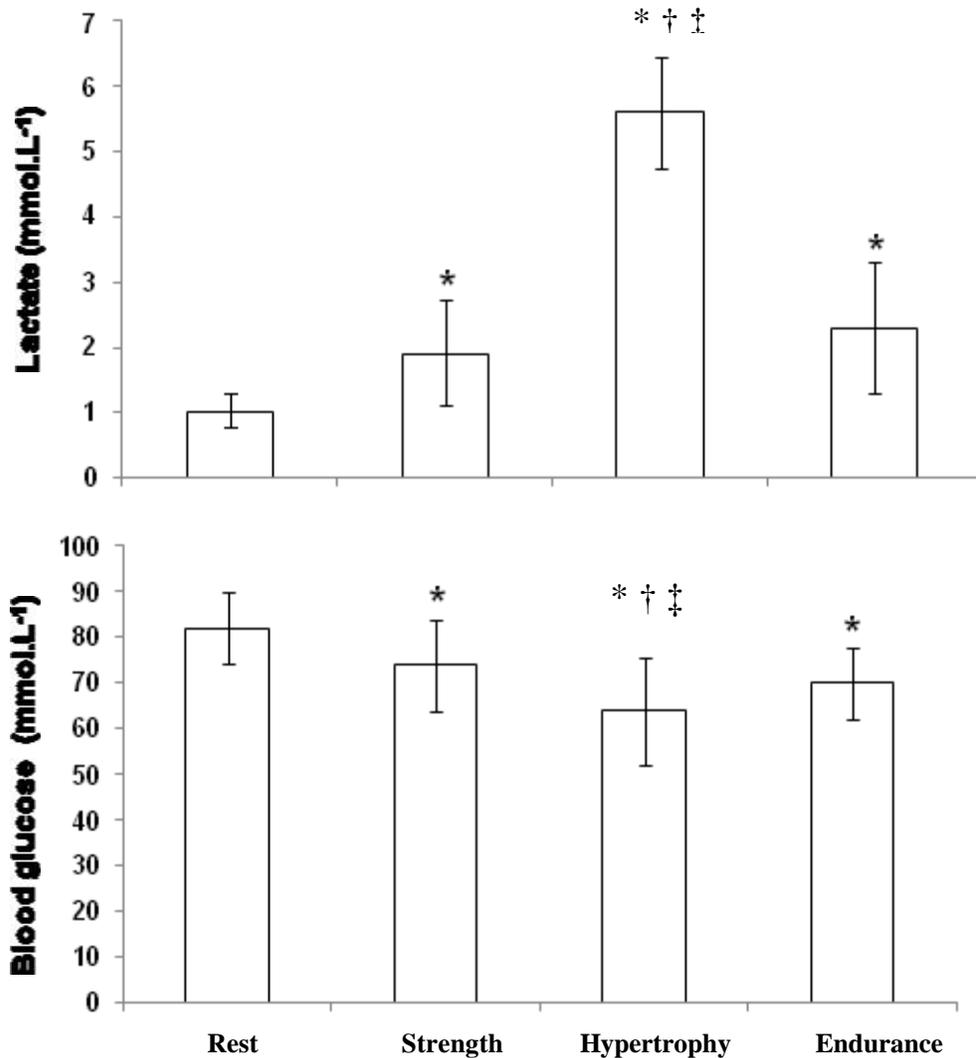


Figure 1. Metabolic Responses in the ACSM Strength Training Protocols for Beginners. *P=0.05 to rest; †P=0.05 to strength; ‡P=0.05 to muscular endurance.

Strength training performed in accordance with the ACSM's recommendations for untrained subjects resulted in significant, but moderate alterations in HR, RPP, and DBP when compared to rest. The SBP values are different among the protocols, but not when compared to values at rest. On the other hand, the MBP was decreased when compared to values at rest in all protocols. Fleck (8) analyzed the SBP in two sets of the leg press exercise at an intensity of 95% of 1RM. The peak blood pressure achieved values as high as 320/250 mmHg.

McCartney et al. (19) studied elderly men who performed a 10-repetition arm curl and leg extension protocol at 80% of 1RM. The subjects' blood pressure values were 247 ± 14 mmHg and 156 ± 9 mmHg for SBP and DBP, respectively. Farinatti and Assis (7) observed MBP values of 137 mmHg during a 6-repetition maximum and of 158 mmHg during a 20-repetition maximum ST protocol. The authors concluded that ST performed at high intensities and low volumes (1RM and 6RM) produced less cardiovascular stress than when performed at high volumes and low intensities (such as 20RM).

In the present study, the DBP values decreased in all protocols when compared to rest. Hypotension after a ST session has been reported by other authors despite the fact that different protocols have been used in those studies. For example, Romero and colleagues (24) reported a decrease in DBP after a ST session in trained subjects using protocols with varied exercises that compared alternate muscle groups with the same muscle groups. Polito and colleagues (22) also reported a decrease in DBP following a ST session shorter than 20 min.

The rate pressure product (RPP) results found in the hypertrophy protocol were also higher when compared to the strength and endurance protocols. Farinatti and Assis (7) observed that RPP is more associated with the number of repetitions rather than with the workload used in the ST session. In the present study, the hypertrophy protocol had more repetitions than the strength protocol and the RPP values were higher. On the other hand, the endurance protocol exceeded the hypertrophy protocol in repetitions, and the results still showed higher RPP values in the hypertrophy session. One possible explanation for this is that the workload/repetitions ratio in the endurance protocol was not sufficient to elicit high RPP responses when compared to the hypertrophy protocol.

The hypertrophy, endurance, and strength protocols showed a significant decrease in glucose values when compared to the same responses at rest. However, the hypertrophy protocol demonstrated a greater decrease in GLU values when compared to the other two protocols.

According to Brun et al. (5), the production of hepatic glucose in sedentary subjects is not enough to maintain glycemia due to the high uptake of glucose by skeletal muscle. Therefore, the control of hepatic gluconeogenesis in untrained subjects performing moderate exercise might be inefficient. There is also an increase in the phosphorylation of proteins related to glucose uptake by the skeletal muscle during exercise, which results in a higher amount of translocated GLUT-4 to the cell membrane. The latter response results in a subsequent enhancement of glucose uptake by the active muscle (25).

Regarding lactate concentrations, the hypertrophy protocol led to the release of higher levels of serum LAC after the exercise session. The determination of lactate in the blood is directly related to the stress produced in conditions similar to high intensity exercise, such as ST. Our findings are in agreement with Kraemer and colleagues (16) who reported an increase in LAC concentrations in body builders and weight lifters after a hypertrophy protocol with short resting periods between sets. The protocol consisted of 3 sets at an intensity of 10RM with 10-sec, 30-sec, and 60-sec intervals between sets. Due to the short resting period, all protocols resulted in an abrupt increase in serum LAC. In addition, Frey et al. (9) suggested that exercise performed at high intensities produces more LAC concentrations compared to a high training volume exercise.

In the ST hypertrophy and endurance protocols, the subjects' RPE values were higher when compared to the strength protocol. In this regards, Gearhart et al. (10) reported on RPE during both a high intensity protocol (9 repetitions at 90% of 1RM) and a low intensity protocol (15 repetitions at 30% of 1RM). The subjects' RPE was higher with the high intensity protocol with fewer repetitions at

a higher percent of 1RM versus the low intensity protocol with more repetitions at a lower percent of 1RM.

The findings from this study demonstrated that the strength protocol (high intensity and low volume) presented a lower RPE compared to the endurance protocol (low intensity and high volume). This could be explained by the period of exposure to the exercise stress. It is known that the longer the exercise is performed the higher is the sensation of the stress and, therefore, RPE is higher. When it comes to the number of repetitions, it is simple to characterize RPE profile, since a higher amount of work (repetitions and/or workload) leads to a higher perceived exertion (27).

A common effect of ST in untrained individuals is muscular tissue damage, which is believed to represent damage to the myofibrils in consequence of the physical exertion. In ST, muscle tissue damage (20) occurs during the initial period of the training program (1). One way to determine the damage in skeletal muscle is to analyze creatine kinase activity (18). The analysis indicated that the hypertrophy protocol produced more muscle damage than the endurance and strength protocols. The high intensity used in the hypertrophy protocol is likely the reason for the higher muscle tissue damage, especially among untrained individuals who use inactive muscle fibers when starting a training regimen.

Almeida (1) compared the effects of a strength training session in untrained subjects using two different protocols. One group performed 3 sets of 15RM with 2-min intervals between sets in 8 different ST exercises. The other group performed the same 8 exercises using a circuit training method, 24, 48, and 72 hrs after the intervention. The CK activity values for the multiple set sessions with a 30-sec period between the sets were 371 ± 597 $\mu\text{mol/ml}$, 800 ± 609 $\mu\text{mol/ml}$, and 1300 ± 631 $\mu\text{mol/ml}$ (24 hr interval), respectively, and 190 ± 248 $\mu\text{mol/ml}$, 219 ± 495 $\mu\text{mol/ml}$, and 145 ± 631 $\mu\text{mol/ml}$ for the circuit training session.

Kleiner et al. (14) compared creatine kinase activity in young trained individuals using different exercise intensities via isokinetic equipment (50°/sec, 100°/sec, and 200°/sec) until voluntary exhaustion. There were no differences in the creatine kinase activity among the different intensities determined immediately after the intervention (50°/sec = 73.3 ± 9.5 U.I, 100°/sec = 91.6 ± 19.3 U.I, and 200°/sec 73.0 ± 16.7). However, they concluded that the intensities used in the intervention were not great enough to promote muscle tissue damage.

CONCLUSIONS

Among the three ST protocols recommended by ACSM for untrained subjects, the hypertrophy protocol promoted muscle tissue damage, high lactate concentration, and hypoglycemia. In regards to the acute physiological responses measured, only moderate alterations were found in the subjects. We suggest that untrained subjects perform the muscular endurance and strength protocols before performing the hypertrophy protocol to avoid excessive skeletal muscle damage and hypoglycemic.

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