

The effect of eight weeks of strength, endurance and concurrent training programs on the upper and lower body strength

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Annotation:

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Aim: The purpose of this study was to investigate the effect eight weeks (three days per week) of strength, endurance and concurrent training programs on strength gains of the upper and lower body in male university students.

Material: For this purpose 32 active boy students from university of mohaghegh ardabili randomly selected to participate in the present study. These subjects were randomly assigned to one of four groups: Strength training (S; N=8, 21.5 ±1.7 years), Endurance training (E; N=8, 20.7 ±1.8 years), Concurrent training (ES; N=8, 21.5 ±1.6 years), and Control group (C; N=8, 21.63 ±1.71 years). The following measurements were made on all subjects before and after eight weeks of training: weight, percent fat, one repetition maximum (1RM) leg press, 1RM shoulder press, 1RM bench press, 1RM squat.

Results: Improvements in 1RM in all movements were significant in all training groups ($P \leq 0.05$) but were significantly greater in the S and ES groups as compared to the E group. There was no any significant difference in the strength gains between S and ES groups ($P \leq 0.05$). In the present study strength gains on upper body in the S and ES groups showed little difference whereas discrepancy in strength gain in the lower body was higher in the two groups. The C group showed decrease significantly in 1RM in all movements. The decrease strength in lower body was less than upper body in C group ($P \leq 0.05$).

Conclusions: These findings indicates that no significant difference in strength gains on the upper and lower body between subjects performing concurrent endurance and strength training or strength training only.

Key words:

one repetition maximum, maximal strength, male university student, leg press, shoulder press, bench press.

Айдин Валізадех, Намидреза Азмоон. Ефект восьми тижнів інтенсивного розвитку сили, витривалості і альтернативних тренувальних програм для верхньої і нижньої частки тіла.

Мета: метою роботи є дослідження ефективності восьми тижнів (три рази на тиждень) розвитку сили, витривалості і паралельних тренувальних програмах підвищення сили верхньої і нижньої частки тіла в чоловічих університетах.

Матеріал: для цієї мети були випадковим чином вибрані 32 активних студента університету. Випробовувані були випадковим чином відібрані в чотири групи: тренування по збільшенню сили (S; N=8, вік 21.5 ±1.7 років), тренування на витривалість (E; N=8, вік 20.7 ±1.8 років), альтернативна тренувальна програма (ES; N=8, вік 21.5 ±1.6 років), контрольна група (C; N=8, вік 21.63 ±1.71 років). Були виконані наступні виміри для всіх груп до і після восьми тижнів тренування: вага, відсоток жиру, кількість максимальних повторень (1RM) для нижніх і верхніх кінцівок, а також станової сили і присідань з вагою.

Результати: підвищення кількості максимальних повторень у всіх рухах були істотні у всіх учбових групах ($P \leq 0.05$) але були значно більші в групах S і ES в порівнянні з групою E. Не спостерігалось істотної відмінності у чію-небудь користь між групами S і ES ($P \leq 0.05$). Показник сили верхньої частки тіла в групах S і ES укаже на невеликі відмінності і перевагу сили в нижній частці тіла в двох групах. Група C показала зменшення значень 1RM у всіх рухах. У групі C зменшення сили в нижній частці було меншим, ніж у верхній ($P \leq 0.05$).

Висновок: отримані дані укаже на відсутність принципових відмінностей в силі у вправах для верхніх і нижніх кінцівок на всіх напрямках, а також в альтернативних тренувальних програмах і тренувань на розвитку тільки сили.

Айдин Валізадех, Намидреза Азмоон. Эффект восьми недель интенсивного развития силы, выносливости и альтернативных тренировочных программ для верхней и нижней части тела.

Цель: целью работы является исследование эффективности восьми недель (три раза в неделю) развития силы, выносливости и параллельных тренировочных программах повышения силы верхней и нижней части тела в мужских университетах.

Материал: для этой цели были случайным образом выбраны 32 активных студента университета. Испытуемые были случайным образом отобраны в четыре группы: тренировка по увеличению силы (S; N=8, возраст 21.5 ±1.7 года), тренировка на выносливость (E; N=8, возраст 20.7 ±1.8 года), альтернативная тренировочная программа (ES; N=8, возраст 21.5 ±1.6 годы), контрольная группа (C; N=8, возраст 21.63 ±1.71 года). Были выполнены следующие измерения для всех групп до и после восьми недель тренировки: вес, процент жира, количество максимальных повторений (1RM) для нижних и верхних конечностей, а также становой силы и приседаний с весом.

Результаты: повышение количества максимальных повторений во всех движениях были существенны во всех учебных группах ($P \leq 0.05$) но были значительно больше в группах S и ES по сравнению с группой E. Не наблюдалось существенного различия в чью-либо пользу между группами S и ES ($P \leq 0.05$). Показатель силы верхней части тела в группах S и ES указывает на небольшие различия и превосходство силы в нижней части тела в двух группах. Группа C показала уменьшение значений 1RM во всех движениях. В группе C уменьшение силы в нижней части было меньше, чем в верхней ($P \leq 0.05$).

Заключение: полученные данные указывает на отсутствие принципиальных различий в силе в упражнениях для верхних и нижних конечностей во всех направлениях, а также в альтернативных тренировочных программах и тренировок на развития только силы.

повторення, максимальна, сила, чоловічий, університет, ноги, плечі.

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Introduction

From physiological point of view, the purpose of training on improvement of different systems of body functions is to optimize athletic performances. Training causes an increase of work capacities and skill abilities of the athletes. Every training has a main and prevailing ability. In a training or sport, rarely only one main and prevailing ability is considered, because one prevailing movement often needs a combination of two or more abilities (1).

Countless numbers of athletes and recreational workout enthusiasts complete their endurance and strength training workouts during the same training session, or within hours of one another. This sequential exercise regime is referred

to as 'concurrent training'. However, these two methods involve different levels of training volume, intensity and duration. Strength training is defined as a low number of repetitions performed on a load that is of high resistance, producing a maximal or near-maximal contraction. In contrast, endurance training is defined as repeated sub-maximal contractions with loads of low resistance (2). When performed independently, these two distinct forms of training induce for the most part, opposite physiological adaptations within the muscle.

Strength training reported to be responsible in muscle fiber hypertrophy, associated with an increase in maximal contractile force (3). Strength training also reduces the mitochondrial density and decreases the activity of oxidative enzymes, which can impede the endurance

capacity but has a minimal effect on capillary density or the conversion from fast (type II) to slow twitch (type I) fiber types (2, 4, 5). In contrast, however, endurance training usually induces little or no muscle hypertrophy, but increases the mitochondrial content, citric acid enzymes, oxidative capacity, and the possibility of muscle fiber conversion from fast to slow twitch (5).

Athletes involved in many sports often perform strength and endurance training concurrently in an effort to achieve adaptations specific to both forms of training. Up to now, researches on the neuromuscular adaptations and performance improvements associated with concurrent strength and endurance training has produced inconsistent results (6).

In 1980, Hickson found that strength development negatively affected by endurance training (7). Similar detriments to strength have been supported by other researches (4, 8, 9). In contrast, however, studies have also found that endurance training has no detrimental effect on strength development (2, 11, 12, 13, 14). Interestingly all agreed that concurrent strength and endurance training has no negative effect on endurance. Strength and endurance training regimes represent and induce a distinctly different adaptive response when performed individually. Typically, strength-training programs involve large muscle group activation of high-resistance low-repetition exercises to increase the force output ability of skeletal muscle (2). On the other hand, endurance-training programs utilize low-resistance, high-repetitions exercises such as running or cycling to increase VO_2 max. Accordingly, the adaptive responses in skeletal muscle to strength and endurance training are different and sometimes opposite (15).

Abernerthy and Quigly (1993) noted that lower body strength development appears to be compromised when the lower limbs are engaged in simultaneous endurance and strength exercises (3). However, concurrent training may not restrict the development of upper body strength. Base on literature reviews surveys done in this particular area, only two studies published on the upper body adaptations (3, 12) and therefore, more research is necessary regarding the effect concurrent training on upper strength development. The purpose in this study was investigation on the strength gains of the upper and lower body during three different training programs after eight weeks strength, endurance and concurrent training.

Methods

Subjects

Thirty-two male university students participated in the study. They did not do any in any regular training program for at least one year. All subjects gave written consent after having being informed about the study protocol, without being informed of the goal of the study. Then they allocated in four groups of: strength-endurance (SE) training, endurance training (E), strength training (S) and control (C) based on biomotor abilities obtained from the tests. Individual particulars of the subjects presented in Table 1.

Material and Methods:

The following measurements done before starting the training program and after completion of eight weeks of training:

Maximal oxygen consumption

Maximal oxygen consumption was used to identify the level of fitness and classify the subjects into two homogenized groups. Maximal oxygen consumption was calculated through Astrand Treadmill Test. In Astrand Treadmill Test, the subjects ran with a speed of 8.05 km.h (5-mile. hour) and with gradient of 0% on treadmill; after 3 minutes gradient of the treadmill increased 2.5%, then every 2 minutes, gradient of the treadmill increased 2.5%. The test continued until exhaustion. Testing time was measured and recorded up to two decimals in minute and was used considering the following assessment equation in functional form to evaluate maximal oxygen consumption.

Maximal Consumed Oxygen (milliliter.kilogram. minute) = $(1.444 \times \text{min}) + 14.99$

Maximal Strength

Maximal Strength in four moves of bench press (BP), shoulders press (SP), squat (SQ) and leg press (LP) calculated by using Berezhicki equation. In this test, subjects choose a heavy weight fairly that was able to lift for over one and less ten repetitions. Then repetitions number and the moved weight in the following equation was used to calculate one maximal repetition (16).

One max repeat = moved weight (kg) \div $(1.278 - 0.0278 \text{ number of repeats})$

Fat Percentage:

Fat percentage was calculated by using Lange caliper and through 3-point equation of Jackson-Pollock (for men) after measurement of under the skin fat thickness in three areas of abdominal, thigh and pectoral folds and by using the following formula:

Density = $1.1093800 - S \times 0.000826 + S^3 \times 0.0000016 - \text{age} \times 0.0002574$

Fat percentage = $495 \div (\text{density} - 450) S = \text{total fat}$

Training Protocols

Each group, performed three sessions of training in a week and during eight weeks maximum 24 sessions of training were done. These 24 sessions were divided into three 8-session sections that in every of these sections specific training program were done. ES, E and S training groups on Sundays, Tuesdays and Thursdays did their training programs. Endurance-Strength (ES) group at the beginning of each training session and after general warming up the body that lasts 15 minutes performed endurance training and after 10 minutes of taking inactive rest, performed strength training.

Endurance Training Program

Endurance training was performed in the form of running and during the 8-week of training time and intensity of activity was increased. In the first 8 sessions (1-8), the subjects trained for 25 minutes with 65% of maximal heart rate and in the second 8 sessions (9-16) for 35 minutes with 65%-75% of their maximal and in the last 8 sessions (17-24), the subjects trained for 40 minutes with 75% to 85% of their maximal heart rate. All the subjects during endurance program, worn a heart rate monitor chest strap (Polar Electro, Finland) for determination of intensity of their training. Also, the subjects were trained to get their pulse from radial artery so that in case of

Table 1

Subject characteristics in four groups

LBM(kg)	kg(%)Fat	(kg)weight	(cm)Height	(yr)Age	N	Group
54.13 ±3.57	9.03 ±2.62	59.48 ±4.10	170 ±4.49	21.5 ±1.60	8	SE
54 ±5.58	12 ±4.63	62.61 ±4.72	170 ±8.91	21.57 ±1.71	8	S
56.07 ±7.58	11.27 ±4.34	66.41 ±4.75	173 ±5.16	20.75 ±1.83	8	E
44.89 ±6.85	11.07 ±2.12	62.58 ±7.41	173 ±5.86	21.63 ±1.71	8	C

Values are given as mean ± SD.

SE = Strength-endurance training E = Endurance training.

S = Strength training C = Control Group N = number of subjects.

Table 2

The comparison of maximal strength before and after 8-weeks of training

significance	t-value	Posttest	Pretest	Group	variable
0.014	-3.265	0.908 ±0.094	0.841 ±0.070	E	Bench press (kg/body weight)
0.000	-15.216	1.035 ±0.183	0.849 ±0.182	S	
0.003	-4.174	1.100 ±0.121	0.917 ±0.139	SE	
0.000	8.257	0.784 ±0.096	0.850 ±0.104	C	
0.002	-4.619	0.683 ±0.082	0.611 ±0.073	E	Shoulder press (kg/body weight)
0.000	-7.984	0.760 ±0.084	0.543 ±0.054	S	
0.000	-6.782	0.839 ±0.056	0.602 ±0.050	SE	
0.001	5.837	0.543 ±0.048	0.586 ±0.040	C	
0.000	-11.380	3.479 ±0.498	2.456 ±0.571	E	Leg press (kg/body weight)
0.000	-21.790	3.954 ±0.257	2.452 ±0.167	S	
0.000	-10.721	4.146 ±0.477	2.735 ±0.370	SE	
0.001	5.968	2.081 ±0.310	2.291 ±0.376	C	
0.000	-11.896	2.024 ±0.371	1.630 ±0.330	E	Squat (kg/body weight)
0.000	-13.003	2.165 ±0.157	1.456 ±0.212	S	
0.000	-9.274	2.401 ±0.515	1.788 ±0.370	SE	
0.003	10.412	1.466 ±0.214	1.642 ±0.246	C	

The mean difference is significant at the 0.05 level.

Table 3

Statistical results between groups

Intra-group differences		Bench press		Shoulder press		Leg press		Squat	
		Sig.	F	Sig.	F	Sig.	F	Sig.	F
E	S	0.029	16.2	0.004	23.8	0.001	64.5	0.000	55.7
E	ES	0.027		0.000		0.003		0.002	
E	C	0.000		0.000		0.000		0.00	
S	ES	0.966		0.541		0.486		0.168	
S	C	0.000		0.000		0.000		0.000	
ES	C	0.000	0.000	0.000	0.000				

The mean difference is significant at the 0.05 level.

appearance of any problem in polar, the subjects could assess the accurate intensity of their training (17).

Strength Training Program

Strength trainings were done 3 times in a week and included bench press, leg press, shoulder press, flexion and extension knee, push up, Squat and forearm by halter. During the first 8 sessions [1-8] of training, the subjects trained with a load of 50-60% of a maximal repeat. 10-15 repeats in every set and 3-4 sets in every training session were done. During the second 8 sessions [9-16] of training, the subjects trained with a load of 60-70% of a maximal repeat in 3-5 sets and 10-12 repeats. During the

last 8 sessions [17-24] of training, the subjects performed strength training with a load of 70-80% of a maximal repeat in 3-5 sets with 8-12 repeats in every session (8).

Statistical analysis

In this research, we employed paired t-test to assess inter-group difference and One Way ANOVA test for assessment of intra-group changes, and at the moments that F measures in ANOVA test got significant, LSD following test was used for determination of differences between the groups. It must be mentioned that study on intra-group changes were done based on differences of average of each group in pretest and post-test. All statistical analysis was done by SPSS Software

and drawing of the diagrams was done by Excel software. A significant level was set at $p \leq 0.05$.

Results

Measurements related to the studied variables presented in the table 2. There was no significant difference between S, E, SE, and Control groups in pretest that would show random distribution and homogeneity in the research sample. After 8 weeks performance of training programs, measurements were repeated in the LP, SP, SQ and BP groups. Table 2 shows statistical results related to changes of variables from pretest until after test in three research groups.

Table 3 shows statistical results related to intra-group differences in the studied variables according to differences of average of each group in pretest and post-test.

Discussion

Maximal strength:

As a result of 8 weeks of training, all training groups showed a significant increase in strength. In this relation, Glowacki (2004) obtained the same results and expressed significant increase of strength in all training groups (18). On the other hand, results of the present research are contrary to the results that reported by Leveritt (2003) by fulfillment study on 26 active students who trained 3 days per week. In this study, author reported significant increase in the strength in the strength and concurrent groups (19). Probable mechanisms of strength increment in follow of strength training can be a result of increment in number of neural impulses of movement units, increase of size of muscular fibers type I and type II and increase in anabolic hormones (8). In addition, plausible mechanisms of increase in strength during endurance training can be related to neural-muscular adaptations and better blood pumping to the muscle that occurs in result of fulfillment of endurance trainings and increase of strength in concurrent training group.

Strength group was at the highest level in the development of strength in bench press, leg press, shoulder press and squat among the groups, and after that the highest increase showed in the concurrent training group after the eight weeks. Additionally, in strength between the strength and concurrent groups, there was not a significant difference. Lack of significant difference between these two groups represents this fact that the combination of strength training and endurance training is not an inhibitor factor in improving and increasing the maximal strength. The results are consistent with studies that expressed concurrent training does not have significant effect on improving strength (8, 18, 20, 21). One possible reason might be short training period in two groups.

In the present study gains strength on upper body S and ES group showed a little difference while discrepancy in strength gains lower body between two groups was higher. Results of the present study is in agreement with studies that expressed lower body strength development appears to be compromised when the lower limbs are engaged in concurrent endurance and strength training (3, 13). Factors related to lower strength in the concurrent group than the strength group may possible related to the endurance training protocol. In the concurrent group, muscle fatigue in result of endurance training performed just before strength training would conflict with physiological adaptations, endocrine changes and altering the balance of anabolic and catabolic hormones.

The mode of endurance training has a considerable role in strength improvement. When primary form of endurance training is running, it may make more noticeable performance hindrance in strength training than other forms of endurance training. Because running is very physically demanding on the lower body muscle, strength training of the lower body will be affected, and strength and power output levels will most likely not be as great as they would be affected in strength training alone. Studies done comparing the mode of cycling or rowing have shown inconsistent results on performance affects (6).

Residual fatigue has been suggested to occur following the endurance component of a concurrent program, which may compromise the ability of muscles to develop tension during the strength element of concurrent training. If sufficient tension cannot be generated during the strength component of the concurrent program, optimal strength development and adaptations may not occur. It has been suggested by Craige et al (1991) that if the endurance training is performed prior to the strength training, residual fatigue may impair muscular force output and thus impairs strength development (22). Conflicting physiological adaptations as a result of concurrent training in skeletal muscles levels can be an effect on gain strength. Furthermore, endocrine changes can be responsible in less development of strength in the concurrent training group.

Concurrent training altering the balance of anabolic and catabolic hormones may reduce fibre hypertrophy and consequently, strength development (6). Kraemer et al (1995) showed that strength training interventions altered testosterone: cortisol ratio levels in favor of anabolism. They also suggested that the endurance element of concurrent training programs could create a more catabolic environment (relative to strength training in isolation), and this in turn may inhibit strength development (10).

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