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THE EFFECT OF TWO SEQUENCE PATTERNS IN RESISTANCE TRAINING ON STRENGTH, MUSCULAR ENDURANCE AND CIRCUMFERENCE IN NOVICE MALE ATHLETES

UČINAK DVA RAZLIČITA OBRASCA TRENINGA SNAGE NA SNAGU MALIH I VELIKIH MIŠIĆNIH SKUPINA

Hamid Arazi, Siavash Rahmati, Samira Zaheri

Department of Exercise Physiology, Faculty of Sport Sciences, University of Guilan, Rasht, Iran.

SUMMARY

This study investigated the effects of two sequence patterns in resistance training. A sequence push with pull exercise (SPS /PL) and an alternative push with pull exercise (APS/PL) were employed to study their effects on strength in large and small muscle group. For this purpose, 24 healthy male athletes were recruited to participate in this study. Subjects (age 20.45 ± 1.99 years; height 173 ± 3.87 cm; Body fat 14.54 ± 2.52%) had a history of at least 3 to 6 months resistance training. The subjects were randomly divided into 3 groups; a control group (n=8), and two resistance training groups: a group using the sequence push with pull exercise pattern (n=8); and a group using the alternative push with pull exercises pattern (n=8). The subjects trained for 10 weeks with similar volume as the first two weeks with 60% 1RM (12 repetitions) that were terminated by the fifth two weeks with 80% 1RM (8 repetitions). 3 sessions per week consisted of 6 exercises leg extension, leg curl, rowing, bench press, biceps curl, and triceps extension. Before and after 10 weeks muscular endurance and strength were measured. The data were analyzed using analysis of variance (ANOVA). When appropriate, Scheffe post hoc test comparisons were used to determine pair wise differences. Significance in this study was set at ($P < 0.05$). The results did not indicate any significant differences between the two training groups in strength and endurance on upper and lower body muscles. Also, there were no significant differences in weight, arm and thigh circumference ($p \geqslant 0.05$). Only differences were significant for biceps endurance and triceps endurance ($P < 0.05$). So, it can be concluded that both the training patterns cause to increase strength in sequence push with pull exercise and alternative push with pull exercises. However, probably alternative push with pull exercise is more appropriate than sequence push with pull exercises for increasing muscular endurance in biceps and triceps.

Key words: resistance training, alternative push with pull exercises, sequence push with pull exercise.

SAŽETAK

Cilj istraživanja je bio istražiti učinak dvaju različitih obrazaca (redoslijeda) treninga snage: push-pull treninga i alternatvnog push-pull treninga na snagu malih i velikih mišićnih skupina.

U istraživanju je sudjelovalo 24 zdravih sportaša (prosječne dobi 20.45 ± 1,99 godina, visine 173 cm ± 3.87, postotka masti 14.54 ± 2.52%) koji su unatrag najmanje 3-6 mjeseci provodili trening snage.

Ispitanici su slučajnim odabirom podijeljeni u tri grupe; kontrolna grupa (n = 8) te dvije grupe treninga snage: grupa koja je provodila push-pull trening (n = 8) i grupa koja je provodila alternativni push-pull trening (n = 8). Ispitanici su trenirali 10 tjedana sličnim intenzitetom; prva dva tjedna s 60% 1RM (12 ponavljanja), tri puta tjedno, a trening se sastojao od šest vježbi: vježbe za noge (ekstenzija, fleksija), veslanje, bench press, biceps pregib i ekstenzija tricepsa. Prije i nakon deset tjedna vježbanja izmjereni su mišićna izdržljivost i snaga.

Podaci su analizirani pomoću analize varijance (ANOVA). Statistički značajna razina testirana je na razini značajnosti ($p < 0,05$).

Rezultati istraživanja ne ukazuju na postojanje statistički značajne razlike između dviju grupa treninga snage u izdržljivosti i snazi mišića gornjih i donjih ekstremiteta. Također, nije pronađena značajna razlika u masi, opsegu ruke i natkoljenice ($p \geqslant 0,05$), a jedina značajna razlika je uočena kod testova izdržljivost mišića bicepsa i tricepsa ($p < 0,05$).

S obzirom na dobivene rezultate može se zaključiti da oba redoslijeda (obrasca) treniranja uzrokuju povećanje snage iako je vjerojatno alternativni push-pull trening prikladniji za povećanje izdržljivosti mišića bicepsa i tricepsa.

Ključne riječi: trening snage, "push i pull" vježbe, redosljed vježbi

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INTRODUCTION

The popularity of resistance training has increased in recent times (22). Traditionally, resistance training was performed by few individuals (e.g., strength athletes and those who strived to gain muscle hypertrophy such as body builders) (23). Reports indicate that youth resistance training may improve motor performance skill (25), may reduce injuries in sport and recreational activities, (3, 13) and may favorably alter selected anatomic (30) and psychosocial parameters (14, 38). Resistance training is now a popular form of exercise that is recommended by national health organizations such as the American College of Sports Medicine and the American Heart Association (2, 1, 21). However, designing a resistance training programme is a complex process that incorporates several acute programme variables (1, 24) and key training principles (9). The effectiveness of a resistance training programme to achieve a specific training outcome (i.e. muscular endurance, hypertrophy, maximal strength, or power) depends on manipulation of the acute programme variables (1, 24). One of these variables is Sequence of Exercise on performance and training adaptations. Exercise order refers to the sequence of resistance exercises in a training session (35). Traditional exercise order dictates large muscle group or multipoint exercises should be performed before small muscle group or single joint exercises, because this exercise sequence may result in the greatest long-term strength gains (36). Sforzo and Tobey (32) examined the effect on muscular performance of manipulating exercise order in weight-trained men. Studies have shown that placing an exercise early vs. later in the workout will affect acute lifting performance (22). In contrast, previous studies showed exercise order can promote a higher power development when the exercise is placed at the end of a single training session despite reductions in total work and number of repetitions performed per set. Furthermore, some authors suggested that small to large exercise order may have beneficial physiological and psychological outcomes and potentially influence exercise adherence in initial training stages (36). Studies show that multiple-joint exercise (bench press, squat, leg press, and shoulder press) performance declines significantly when these exercises are performed later (after several exercises stressing similar muscle groups) rather than early in a workout (33, 35). Sports medicine research has indicated that exercise order is an important variable that affects both acute responses and chronic adaptations to RT programs (34). Altering one of the exercise order variables will affect the training stimuli, thus creating a favorable condition by which numerous ways exist to vary resistance training programs and maintain/increase participant motivation (22). By this way may facilitate achievement to desired goals. Athletes are trying to the achievement to procedures so that result in increase Strength and muscular endurance. So, one of the procedures can be successful for athletes to recruit training exercise in a style of either alternative push with pull exercises or sequence push with pull exercises. These types of workouts are most popular among body builders or individuals striving to maximize muscle hypertrophy (23). However, the Effectiveness of both patterns of training sequence still is not clear on potential muscular stimulation. In this regard, we noted two training sequence patterns that are Common form of resistance training programs used by athletes who need to develop strength and muscular endurance. This pattern is recruitment of continuous and intermittent exercises that can cause different muscles stimulation. These exercises may have different outcomes. Furthermore, the effectiveness of this pattern of sequences is not yet clear. Few studies have compared different types of exercise order in resistance training programs. Therefore, the aim of this study was to compare the effectiveness alternative push with pull exercises with sequence push with pull exercises on large and small muscular groups in order to increase strength and muscular hypertrophy during 10 weeks.

METHODS

Subjects

24 healthy male athletes participated voluntarily in this study. The subjects were randomly divided into three groups: group I (SPS /PL) (n = 8), group II (APS/PL) (n = 8), group III (Control) (n = 8). Subjects were informed as to the experimental procedures. Then the subjects received and completed a health history questionnaire. All Participants were informed of the possible risks and benefits associated with the study prior to the signing of an informed consent form. The subjects had a history of weight training 3 to 6 months. Subjects were asked to maintain their normal dietary intake during the study and to prevent from recruitment of strenuous activities these days. There was no significant difference between the groups in age, height and body fat percent (Table 1).

Table 1. Subjects characteristics. Data are respresented as Mean ± SD
Tablica 1. Opis uzorka . Vrijednosti su prikazane kao AS± SD

	group I (SPS /PL)	group II (APS/PL)	group III (Control)
Age (yr)	21.12 ± 2.41	20.12 ± 1.80	20.12 ± 1.80
Height (cm)	173 ± 4.13	175 ± 3.95	173 ± 3.66
Body fat (%)	15.67 ± 2.50	14.38 ± 2.07	13.56 ± 2.77
Weight (kg)	71.5 ± 5.60	70.81 ± 5.08	74.56 ± 5.92

Testing Procedures

The subjects were familiarized with the resistance training program about one week before the start of training period. During the familiarization session, subject initial characteristics such as; age, height, body weight, body fat percent, thigh and arm circumference, muscle strength in 6 exercises include (leg extension, leg curl, rowing, chest press, bicep curl and triceps extension) and dynamic muscle endurance (60% 1RM) in these 6 exercises, were obtained. Subjects were tested pre training and post training While were performed both sequence push with pull exercise (SPS /PL) and an alternative push with pull exercises (APS/PL) with the same volume (10 weeks). The same researchers conducted all tests. Pre and post training anthropometric measures of weight, and percent body fat were taken. Height was measured to a nearest to 0.1 cm using height rod. Body weight with minimal clothing was measured to the nearest 0.1 kg on a lever-type balance in a fasted state after emptying the bladder. Subjects had 3 skin fold sites (chest, abdominal, and thigh) measured to determine body composition or percent body fat. The measurement was used on basis of the method of Jackson and Pollock (16). The circumference of mid thigh and mid upper arm of the dominant limbs was assessed. The thigh and arm circumference were measured at rest using tape. Upper and lower body muscle strength was measured using McGuigan (27) procedure in the different exercises and also, muscle endurance was measured in muscles which were mentioned with load of 60%1RM (based on number of reps as possible).

Resistance Training

Training was conducted three days a week, with a minimum of 48h between sessions, for 10 weeks. Each session lasted 70 to 80 minutes. The warm up period lasted from 10 to 15 minutes and also the cool-down included stretching exercises for 5 minutes. The total time of resistance training in each session lasted 50 to 60 minutes. Each group was assigned a same volume of the same exercises over the training period. Training program included two sequences of push with pull and alternative push with pull.

Resistance training program for sequence of push with pull:

Each session was conducted by leg extension (3 sets), leg curl (3 sets), rowing (3 sets) and bench press (3 sets); all of these were large muscles. Bicep curl (3 sets) and also triceps extension exercise (3 sets) were small muscles. Sequence means each exercise is performed for 3 sets (with intervals of rest) and then next exercise starts moving again.

Resistance training program for alternative of push with pull:

Each session was conducted by leg extension (1 set) and leg curl (1 set). The alternative means the opposing muscles (requires push and pull) that were trained alternatively.

In the present study training, exercises of leg extension, chest press, and triceps extension required to push and exercises of leg curl, biceps curl and rowing required to pull. In all these training patterns, 2 minutes rest interval was considered between exercises for upper body and 3 minutes between exercises for lower body. The intensity of exercises is according to the table 2. The study protocol was approved by the Ethics Committee of University of Guilan.

Table 2. The intensity of exercises during the ten weeks.
Tablica 2. Intenzitet vježbi tijekom 10 tjedana

Group	Exercise sequence	The first two weeks\ repetitions	The second two weeks\ repetitions	The third two weeks\ repetitions	The fourth two weeks\ repetitions	The fifth two weeks\ repetitions
I	(SPS /PL)	60%1RM\12	65%1RM\12	70%1RM\10	75%1RM\10	80%1RM\8
II	(APS/PL)	60%1RM\12	65%1RM\12	70%1RM\10	75%1RM\10	80%1RM\8

*1RM; one repetition maximum
*Each of various exercises performance was tested every two weeks and every two weeks, exercises performed based on the new 1RM for each person.

STATISTICAL ANALYSIS

Descriptive statistics (mean ± SD) for age, height, and weight were calculated. This provided data that examined whether the subjects in the three groups differed before training. The data were analyzed using analysis of variance (ANOVA) to determine any differences among groups. When appropriate, Scheffe post hoc test comparisons were used to determine pair wise differences. Paired t-tests were used to identify any significant differences within the groups at the pre and post tests for the dependent variables. Significant level was set at $P<0.05$ and the analyses were conducted using the SPSS software 16.0.

RESULTS

The results of this study are presented in table 3, 4 and 5. There were significant changes in muscle endurance in six used exercises, after 10-weeks resistance training for two training groups (P < 0.05) (Table 5). But, there were no significant differences (p > 0.05) in thigh and arm circumference (Table 3) and also, on strength in used exercises (table 4) and muscular endurance except to triceps endurance and biceps endurance between two training groups for the selected exercises (Table 5). The results in table 4 indicates significant difference (P<0.05) within a group between pre and post-training in six used exercises.

Table 3. Arm and thigh circumference (cm) before and after ten weeks resistance training.
Tablica 3. Opseg bicepsa i tricepsa nakon 10 tjedana treninga. Vrijednosti su izražene kao maksimalne vrijednosti jednog ponavljanja.

Group	Pre-training	Post-training	Pre-training	Post-training
	Arm (cm)		Thigh (cm)	
(SPS /PL)	21.875 ± 2.615	22.562 ± 2.569*	36.125 ± 5.111	37.062 ± 5.192*
(APS/PL)	22.437 ± 2.846	23.062 ± 2.704*	37.562 ± 4.632	38.187 ± 4.802*
CON	22.125 ± 2.9	22 ± 2.828	36.562 ± 6.349	36.437 ± 6.394

Data are presented as mean ± SD; * indicates significant difference (P <0.05) within a group between pre and post-training. Sequence push with pull exercise (SPS /PL) and an alternative push with pull exercise (APS/PL).

Table 4. Muscular strength (kg) in six exercises before and after ten weeks resistance training.
Tablica 4. Snaga (kg) u šest vježbi prije i nakon nakon 10 tjedana treninga

Group	Pre-training	Post-training	Pre-training	Post-training
	Triceps extension (kg)		Biceps curl (kg)	
(SPS /PL)	29.375 ± 4.172	36.25 ± 6.408*	28.125 ± 7.0394	32.5 ± 7.559*
(APS/PL)	29.375 ± 6.23	34.375 ± 7.288*	26.25 ± 5.175	30.625 ± 5.629*
CON	26.875 ± 5.938	27.5 ± 5.976	23.750 ± 6.408	24.375 ± 6.232
	Leg extension (kg)		Leg curl (kg)	
(SPS /PL)	40 ± 5.345	46.25 ± 5.175*	35 ± 5.976	39.375 ± 5.629*
(APS/PL)	41.25 ± 8.345	47.5 ± 8.017*	35.625 ± 6.232	40.625 ± 8.210*
CON	38.75 ± 5.824	39.375 ± 7.288	32.5 ± 4.629	32.5 ± 3.779
	Rowing (kg)		Bench press (kg)	
(SPS /PL)	27.5 ± 4.629	31.875 ± 5.938*	39.375 ± 9.038	45.625 ± 8.634*
(APS/PL)	30 ± 6.546	35 ± 7.071*	38.125 ± 7.039	44.375 ± 7.288*
CON	30.625 ± 7.763	31.25 ± 6.408	40 ± 9.258	40.625 ± 8.207

Data are presented as mean ± SD; * indicates significant difference (P <0.05) within a group between pre and post-training. Sequence push with pull exercise (SPS /PL) and an alternative push with pull exercise (APS/PL).

Table 5. Muscular endurance (repetitions) in six exercises before and after ten weeks resistance training.
Tablica 5. Mišićna izdržljivost (broj ponavljanja) u šest vježbi prije i nakon 10 tjedana treninga

Group	Pre-training	Post-training	Pre-training	Post-training
	Triceps extension (rep)		Biceps curl (rep)	
(SPS /PL)	17.25 ± 1.832	24.5 ± 2.778* †	18.375 ± 2.387	24.750 ± 3.327*
(APS/PL)	17.875 ± 2.532	26.0 ± 3.545 *†	18.625 ± 2.669	26.499 ± 3.1622*†
CON	17.125 ± 2.100	17.374 ± 3.502	18.125 ± 2.850	19.125 ± 4.578
	Leg extension (rep)		Leg curl (rep)	
(SPS /PL)	19.75 ± 2.915	27.125 ± 3.482*	18.125 ± 2.799	23.75 ± 3.011*
(APS/PL)	18.375 ± 2.445	25.75 ± 3.284*	16.625 ± 1.922	23 ± 2.267*
CON	20.625 ± 4.138	20.25 ± 3.24	18.5 ± 3.338	19 ± 3.854
	Rowing (rep)		Bench press (rep)	
(SPS /PL)	16.125 ± 3.136	21.75 ± 3.807*	19.625 ± 3.461	26.125 ± 4.086*
(APS/PL)	16.625 ± 3.543	23.625 ± 3.7*	19.625 ± 2.503	26.75 ± 3.535*
CON	18.5 ± 3.585	19 ± 2.927	19.25 ± 3.732	19.625 ± 3.814

Data are presented as mean ± SD; * indicates significant difference (P <0.05) within a group between pre and post-training, † significantly different from control. Sequence push with pull exercise (SPS /PL) and an alternative push with pull exercise (APS/PL),

DISCUSSION

The purpose of this study was to examine the effects of two exercises order on muscle strength, endurance and circumference. We hypothesized that, alternative push with pull exercises (APS/PL) are better than sequence push with pull exercise (SPS/PL). The main finding of the present study was that, there were no significant differences between training groups on thigh and arm circumference and also on muscular strength in used exercises and muscular endurance except to triceps endurance and biceps endurance. Triceps endurance and biceps endurance increased significantly in two groups after 10-week resistance training. Previous studies from our research are in agreement with these results and suggest that Force and power may be reduced if the exercises are performed consecutively (26). In the contrast of our study, the sequencing of exercises and number of muscle groups trained during a workout significantly affects the acute expression of muscular strength (32). Simão et al. recommended if the strength and conditioning professional wants to maximize the athlete´s performance in one specific resistance exercise, this exercise should be placed at the beginning of the resistance training session (36). There are many ways to arrange the sequence of exercises in a resistance training session. Most youth will perform total body workouts several times per week, which involve multiple exercises stressing all major muscle groups each session (8).

In this study triceps muscle endurance and biceps muscle endurance increased significantly. in contrast this finding , Kraemer et al reported that the sequencing of exercises for local muscular endurance training may not be important in comparison with strength and power training as fatigue is a necessary component of local muscle endurance training (23). The sequencing of exercises also applies when exercises are sequenced based on agonist/antagonist muscle group relationships (31). The common belief is that agonist muscles provide the torque necessary to propel the limb. Jaric et al have stressed the possible role of antagonist muscles in joint protection since antagonist force often exceeds the level needed for braking (17). A reduction in antagonist co-activation would allow increased expression of agonist muscle force, while an increase in antagonist co-activation is important for maintaining the integrity of the joint (10). On this basis, it have been suggested that early antagonist activity is used to actively terminate the acceleratory phase of the movement (17). There are three basic workout structures: 1) total body workouts (e.g., performance of multiple exercises stressing all major muscle groups per session), 2) upper/lower body split workouts (e.g., performance of upper body exercises only during one workout and lower body exercises only during the next workout), and 3) muscle group split routines (e.g., performance of exercises for specific muscle groups during a workout) (22). Rotation of opposing exercises (agonist-antagonist relationship) is subdivision of latter category. The efficient coordination of agonist and antagonist muscles is one of the important early adaptations in resistance training responsible for large increases in strength or torque (5, 7, 29). Strengthening antagonist leads to an increase in agonist muscle movement speed. Strength training reduces the interfering effect of co-contraction between agonist and antagonist muscles in rapid movements. Jaric et al. demonstrated that increased strength of the antagonist muscles as a result of training resulted in increased speed during ballistic elbow flexion movements (18).

This finding indicates that the contributing role of the nervous system for strength development during the present heavy resistance training combined with explosive exercises may have been of great importance. Large initial increases in biceps and triceps endurance observed during the 10 weeks of strength training can be attributed largely to the increased motor unit activation of the trained agonist muscles (11). The production of maximal forces requires an optimal activation pattern of agonist and antagonist muscle groups, as well as optimal muscle fiber recruitment within a muscle (6). The training-induced adaptations in the neuromuscular system differ according to the specific mode of exercise used for strength training. Nevertheless, most studies seem to support the contention that the adaptation to typical strength training is different when combined with endurance training (12). It was suggested that the nervous system is unable to active the muscles active the muscles maximally during maximum voluntary test performed at specific eccentric and concentric angular velocities because of the inhibitory activity of several nervous, joint, and muscle structures (15, 19, 37, 39). One of the components of this mechanism is the co-activation of the antagonists which is dependent on resistance and angular velocity of the movement and the muscle examined and prevent overloading of the joint and contributes to joint stabilization (20). Increased tension in the musculotendinous unit is detected by proprioceptors in the tendon and muscle (Golgi tendon organ and muscle spindle), which inhibit further agonist muscle contraction and induce relaxation in the antagonist unit (28).

In APS/PL may arrange exercises so that those resulting in extension of joints are alternated with those that flex joints, while In SPS/PL arrange exercises so that those resulting in extension of joints are sequenced with those that flex joints. Extension exercises require that you "push," whereas flexion exercises require you to "pull" thus the name of this arrangement, push (PS) with pull (PL). In triceps and biceps pushing exercises rely on assistance from elbow extension strength from the triceps muscle. When triceps exercise precede pushing exercise, they fatigue the triceps, reducing the number of repetition and the desired effect on the chest and shoulder muscles, respectively. The same logic applies to biceps exercises. Pulling exercises that involve flexion of the elbow, such as the lat pull-down, are dependent upon strength from biceps muscles (4).

CONCLUSIONS

In summary, it can be concluded that both the exercise order patterns cause to increase strength in sequence push with pull exercise and alternative push with pull exercises. this study demonstrates that different training protocols can enhance the muscular endurance of

athletes in opposing exercises (agonist-antagonist relationship) in lower-body, and athletes are involved in sports which upper body muscles is more important, It is suggested to use the opposing exercises for strengthening agonist –antagonist exercises, that is, exercise performed for a muscle group followed by an exercise for the opposing muscle group. The results support the concept of the "interference effect' in strength improvement when strength training is performed concurrently with endurance training. It is possible that was not enough time in this protocol in order to cause the necessary training stimulations to increase strength.

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