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Research Article

Application Of Resistance Training And Strength Exercises For Improving Explosive Force In Students Of Sports University Of Tirana

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ARTICLE INFO	ABSTRACT

Resistance training is a potent stimulus to the neuromuscular system for muscle hypertrophy and strength gain which is known to have positive effects on health, weight control and performance The capacity for human exercise performance can be enhanced with prolonged exercise training, whether it is endurance or strength-based. The purpose of this study is to analyse the effectiveness of RT performed with strength exercises for improving body composition, muscle strength and explosive force of SUT students. 45 male students of SUT, aged 18-25 years old, had participated in this study. The training period lasted 12 weeks with 3 times per week sessions. The study was performed following a training protocol by control and experimental groups. The paired samples t-test was used to the comparisons within group, whilst the independent samples t-test was used to compare variables between groups at baseline. The main findings of this study is that HIRT procedures improvements in the maximum power output (peak power) and efficiency of the motion at experimental group are slightly greater than those reported at control group and the estimated mean change in maximum power output and efficiency over the training program was 4.08 W/kg and 4.2% efficiency ($p < 0.05$) when compared the experimental group to control group. In conclusion, the present study suggest that, the high intensity resistance training program composed by functional training, fitness challenge and core & abdominal exercises have the most benefit form improving body composition, peak maximum power, efficiency and explosive force.

Keywords: *resistance training, strength exercises, explosive force*

Introduction

Physical activity and active lifestyle are well known for the benefits and overall well being for humans. Physical exercise is recognized as an important tool in increasing the energetic cost (Vianna et al, 2011). Regular exercises are well known to improve health and reduce a number of risk factors for chronic disease (Blair et al., 1989). The capacity for human exercise performance can be enhanced with prolonged exercise training, whether it is endurance or strength-based (Hughes et al., 2018). In humans, exercise training and moderate to high levels of physical activity are protective against cardiovascular disease, almost 40% more protective than predicted based on the changes in traditional risk factors than they cause (Joyner & Green, 2009). Endurance exercise is classically performed against a relatively low load over a long duration, whereas strength exercise is performed against a relatively high load for a short duration (Hughes et al., 2018). Resistance exercises can be classified according many different criteria, considering the number of joint involved (Paoli et al., 2017). Resistance training (RT) is a potent stimulus to the neuromuscular system (Deschenes & Kraemer, 2002), for muscle hypertrophy and strength gain, but it is less understood whether RT can increase maximal aerobic capacity (Ozaki et al., 2013). Muscular endurance was defined as the maximal number of repetitions that could be lifted at 60% of their 1 RM weight with full range of motion and no help for each muscle tested for strength (Myers et al., 2015). Resistance training (RT) is known to have positive effects on health (Steele et al., 2017), weight control and performance (Paoli et al., 2015). Cardiorespiratory endurance has long been recognized as one of the fundamental components of physical fitness (Kukeli & Skënderi, 2018a). Many benefits of active lifestyle are associated with higher levels of cardiorespiratory fitness, which may exert protective effects that are independent of traditional risk factors, and additionally, for individuals with low physical fitness, even modest improvements in fitness can have substantial health benefits (Bacon et al., 2013). However, some individuals may have a limited ability to increase their cardiorespiratory fitness in response to endurance exercise training (Bouchard et al., 2011). Endurance training leads to adaptations in both the cardiovascular and musculoskeletal system that supports an overall increase in exercise capacity and performance (Brooks, 2012). Weight training has the effect on capillary and strengthening the muscle and blood vessels, as well as creating conditions for an intervention in fatty deposits in the body (Kukeli & Skënderi, 2018a). In many studies, regular vigorous exercise or occupational physical activity has been shown to reduce the risk of cardiovascular disease by one third to one half, and more importantly very high levels of cardiorespiratory fitness appear to reduce these risks by up to 60-70% (Joyner & Green, 2009). Various forms of exercise intervention typically cause only modest reductions in LDL or increases in high-density lipoproteins HDL (Green et al., 2008). Designing RT programs is difficult due to the great number of variables involved (Paoli & Bianco, 2012), underscoring the proposition that RT should be investigated more thoroughly and rigorously by taking into account these different variables (Gentil et al., 2017). Depending on the specific program design, resistance training can enhance strength, power, or local muscular endurance (Deschenes & Kraemer, 2002). The purpose of this study is to analyse the effectiveness of RT performed with strength exercises for improving body composition, muscle strength and explosive force of SUT students.

Methodology

Materials and Methods

Study participants

Forty five 45 young males (22.54 ± 0.231 years, 178 ±3.2 cm and 82.24.5 ± 3.41 kg) had participated as volunteers in this study. All of them were active students with no previous experience in RT and there were checked by a sport physician for their health conditions before application of the study protocol, to avoid the health risk of any unexpected event during the training session. None of the subjects had clinical evidence of heart disease. The training period lasted 12 weeks with 3 times per week sessions. The study was performed following a training protocol by control and experimental groups. All exercises were performed with 2 sets of 20 repetitions at a 60% of 1 RM and 1 min recovery between sets. The participants were instructed not to change their nutritional habits or restricting calories during this period of study. The study was carried out in according to the recommendations of the rules of the institution. Before the measurements, the volunteers received the explanations about the procedures, as well as the risks involved in the study and were invited to sign the consent form in accordance with Helsinki Declaration. All the procedures were performed on the same gym at a temperature between 15-25 °C.

Instrument and protocols

The study was performed in Biomechanics Laboratory of Sports University of Tirana and all data were recorded in its licensed equipment's. Two main apparatuses utilized for studying endurance performance were: a physician beam scale and force platform. Height body was measured using "Health o Meter" Professional, Model 500KL-BT; ISO 13485:2016; Pelstar, LLC, USA and force plate Leonardo Mechanography (GRF), version 2011. The standard jumping testing protocol was used to collect the data: S2LJ (single two leg jump) test – which is a performance power test for maximum height (countermovement jump), performed using both legs with arm swing. There is empirical evidence that the average height of the jumps is greater than 10% when arms are used, based on the some studies reported (Bendo & Mara, 2020; Luhtanen & Komi, 1979; Shetty & Etnyre, 1989).

Inclusion criteria

In order to investigate the effects of resistance training with strength exercises, we included only studies that used traditional resistance training (TRT) as well as high-intensity resistance training (HIRT) program. Therefore circuit training program was excludes because it aims to improve aerobic capacity. Therefore, in this study are taken in consideration the following criteria: 1) study population from students of SUT which could be healthy and sedentary, untrained or physically active, but not participating in regular strength and endurance training; 2) training intensity and duration in which study had to include training intensities > 50% of one repetition maximum (1RM) (Cadore et al., 2010), and in order to allow a sufficient period of physiological adaption, the duration of the study had to be > 8 weeks (Abe et al., 2000).

Procedure

Pre-test measurements

The training programs lasted 12 weeks and involved 3 weekly RT sessions. After all testing procedures were completed, subjects were randomly assigned to two groups: control group (n = 22) exercised with only with TRT exercises and experimental group (n = 23) with only HIRT program, as shown in Table 1. The procedure in this study consisted of three phases: the first phase, initial. Both groups training period involved three workout days/or session per week. The data for this phase were collected on force plate measurements for S2LJ test for all the participating subjects. In this phase, the pretest data of biomechanical variables for both groups experimental and control group were collected, with the hypotheses that the pretest data of the two groups data didn't have a significant difference on average values.

Training methods

Control group performed Traditional Resistance Training (TRT) which includes a split training system for 3 days of the week respectively: Monday (shoulders & legs exercises), Wednesday (chest and biceps exercises) and Friday (back and triceps exercises). Split training system (Evans, 2007) was designed to exercise all major muscle groups of the body, chest, biceps, and upper exercises were alternated with lower body exercises to avoid extreme overload stress on any muscle group. Experimental group performed High Intensity Resistance Training (HIRT), which includes also a 3 days per week training as following: Tuesday (Functional Training exercises) (Santana, 2016), Thursday (Fitness Challenge) (FCETP, 2023) and Saturday (core and abdominal exercises) (Manocchia, 2011). The second phase includes an exercise training program three times a week, including respective exercises programs for each group with 2 sets of 20 repetitions at a 60% of 1 RM and 1 min recovery between sets, and with duration of 60 minutes, for 12 weeks. This procedure starts with 5-7 min general warm up exercises, following 45 min with the training program for each group and ends with 8-10 min cool down exercises.

Post-test measurements

The data post-test for both groups was collected after two different training methods, and they were used to undergo through statistical procedures.

Table 1. Weekly training programs for control and experimental groups.

Control group Exercises (split training system)	**Experimental group exercises**
Monday (shoulders & legs) Barbell shoulder press Dumbbell shoulder press Dumbbell lateral raise Barbell front raise Bent-over Dumbbell raise Machine rear deltoid fly Barbell squat Leg extension Lunge Lying leg curl Leg Press Hack squat Standing calf raise	**Tuesday (Functional Training)** Front squats press Renegade row Push up Dumbbell chop Pull up knee raises Inverted row Kettlebell swing Up down plank push up Cross-body clean & press Step up to overhead press Lunge with overhead press Feet-elevated push up Close-grip chin up Burpee to broad jump
Wednesday (chest & biceps) Barbell bench press Incline barbell press Dumbbell fly Incline dumbbell fly Chest dip Pec-deck fly Chin ups Barbell curl Dumbbell curl Machine curl Reverse barbell curl Concentration curl	**Thursday (fitness challenge)** Pull ups (lying position) Jefferson squat Dips on bench (feet forward) Lunges (non walking, with dumbbells) Sit ups (weight on chest) Snatches (with kettlebell) Chin ups (prone & strict) Jump squat Dips (feet forward) Walking lunges (with a barbell) Sit ups (weighted) Burpees& Devil press Barbell rollout

Friday (back & triceps)	**Saturday (core & abdominal)**
Wide grip pull up	Elbow plank
Wide grip pull down	Side planks
Machine row	Full plank
Dumbbell row	Bridging Pilates
Dead lift	Side leg lift
Back extension	Donkey kicks
Close grip bench press	Knee crunches
Triceps dips	Leg raises
Seated triceps press	Bicycle crutches
Lying triceps extension	Russian twist
Triceps push down	Ustasanacamel pose
Dumbbell kickback	Hip crossover

Statistical analysis

All the experimental data are expressed as mean and standard deviation. Shapiro Wilks test was used to test the normality of distributions for the measured variables, which corresponded to a normal distribution ($p > 0.05$). The distribution of data (variance) of the experimental and control group was found homogenous, based on the Levenie's test result, which showed a significance vale of $p > 0.05$. The paired samples t-test was used to the comparisons within group, whilst the independent samples t-test was used to compare variables between groups at baseline. The effects of training in each group were assessed to identify the variations of biomechanical variables in each group (control and experimental). The magnitude of variables changes was compared for pre – and post-training in both groups. A probability of $p < 0.05$ was accepted as the minimum value for statistical significance. Data analysis was performed using IBM SPSS software package version 26.

Results

The study was completed on 45 male students of SUT. Results have been reported in pre and post mean values ± SD. Mean values for their physical characteristics were: age: 22.54 ± 0.231 years; height 178 ±3.2 cm; and 82.24± 3.41 kg. There were a statistical significance decrease in body mass and therefore fat mass from pre to post-training measurement ($p < 0.000$) respectively in both groups, but there no significant differences in height between groups ($p = 0.362$) from pre to post-training ($p = 0.217$). The aim of this study was to analyse the effectiveness of RT performed with strength exercises in both experimental and control group in the data taken from pre-test and post-test measurements. Table 2 shows that there are variances in mean for both groups. As it is noticed by the results, the values of Pmax and efficiency are higher for the experimental group compared with the control group.

Table 2. Descriptive statistics of maximum peak power and efficiency data

Variable	Data	Experimental group				Pre-test-post-test mean difference	Post-test mean difference
		Min.	Max.	Mean	SD		
S2LJ P.max (W/kg)	Pre-test	39.87	48.61	43.44	1.08	10.67	4.08
	Post-test	42.03	57.15	54.11	0.39		
		Control group					
	Pre-test	46.44	47.86	44.72	0.82	5.31	
	Post-test	37.19	52.24	50.03	1.23		
S2LJ-Efficiency (%)		Experimental group					
	Pre-test	78.6	88.2	85.1	2.1	9.2	4.2
	Post-test	85.4	96.7	94.3	1.3		
	Control group						
	Pre-test	78.9	87.2	84.2	0.8	5.9	
	Post-test	79.3	92.5	90.1	1.4		

The paired samples t-test and independent samples t-test are analysed for both groups. The paired samples t-test in the table 2 has identified the differences in pre-test and post-test data, showing that p-value ($p < 0.05$) is related with a significant difference between them.

Table 3. Paired samples t-test for pre-test and post-test data for the experimental group and control group.

Variable	Pre-test-Post-test	Paired differences					t-value	df	p-value
		Mean	SD	Std. error mean	95% Confidence				
					Lower	Upper			
S2LJ P.max (W/kg)	Experiment	10.67	0.69	0.208	1.494	2.381	9.636	22	0.000
	Control	5.31	0.81	0.235	5.952	4.914	4.332	21	0.002
S2LJ-Efficiency (%)	Experiment	9.2	0.84	0.382	2.014	5.321	5.653	22	0.000
	Control	5.9	0.93	0.143	4.145	3.817	4.041	21	0.000

The difference of Pmax in experimental is increased after HIRT exercises with a difference of 10.67 W/kg, and an efficiency value of 9.2% (pre-test and post-test mean). Meanwhile the value of Pmax in the control group with TRT exercises was only 5.3 W/kg and the efficiency value of 5.9% (pre-test and post-test mean difference).
Table 4 gives the independent samples t-test for the post-test data for both experimental and control groups. The results show that there is a significant difference between the post-test data of the experimental group and control group.

Table 4. Independent samples t-test for pre-test and post-test data for the experimental group and control group.

Variable		t-test for Equality of Means						
		t-value	df	p-value	Mean Difference	Std. Error difference	95% Confidence	
							Lower	Upper
S2LJ P.max (W/kg)	Equal variances assumed	3.962	43	0.000	4.08	0.45	7.07	5.24
		3.962	2.71	0.000	4.08	0.45	7.07	5.23
S2LJ-Efficiency (%)	Equal variances assumed	2.125	43	0.000	4.2	0.38	6.13	8.72
		2.125	3.18	0.000	4.2	0.38	6.13	8.73

The difference of Pmax and efficiency after training program for both groups (between experimental and control group) was respectively: a value of 4.08 W/kg for Pmax and for efficiency a value of 4.2%, so training program was proven to increase the biomechanical variables in this study.

Discussion

The present study was undertaken to analyse the effects of RT performed with strength exercises on improving body composition, muscle strength and explosive force of SUT students. The t-test SPSS analysis was used to compare the two groups statistically for changes from initial to final tests for each independent variable. Based on the results of this study, Pmax and efficiency in both groups (experimental and control group) were increased after a 12 week program. After training program HIRT to experimental group, the biomechanical variables increased respectively by a value of 10.67 W/kg for Pmax and 9.2% for the efficiency. Meanwhile the Pmax value and efficiency in the control group were: 5.31 W/kg and 5.9% respectively. The difference in mean values for Pmax and efficiency from the post-test data of the two groups showed a significant value of Pmax by 4.08 W/kg and 4.2% efficiency ($p < 0.05$). The decreases in body mass and therefore fat mass is in the line of the previous study that RT might be beneficial to promote fat loss (Paoli et al., 2015). Another study has showed that RT protocols might provide adequate stimuli to increase cardiorespiratory fitness (Paoli et al., 2017). The results of this study are in a line with the previous studies, which reported that TRT and HIRT exercises program may be an important key for preventing risk factors for chronic disease and also protective against cardiovascular disease. Regardless studies have found that adding endurance training to strength training regimens can result in negative effects in both trained individuals; however there are a number of hypotheses that can be applied toward the experience of an individual (Kukeli & Skënderi, 2018b). The results of this study are also consistent with those of other investigations, which have shown that HRT and HIRT training program can improve overall being, especially an increase of explosive force and reduce of body mass. The results of this study are in a line with another study which demonstrated a mean increase of Fmax and Pmax, EFI and efficiency in response of 12 weeks of standardized adult fitness style training ad marked individual variation was observed (Bouchard et al., 2011). The results of the present study show that both TRT and HIRT programs were effective in increasing maximal muscular strength and explosive force.

The main findings of this study is that HIRT procedures improvements in the maximum power output (peak power) and efficiency of the motion at experimental group are slightly greater than those reported at control group, described as adult fitness based continuous training, even though many of the studies were of short duration with limited session per week (Bacon et al., 2013). While the observation that more intense training results in greater increases in cardiorespiratory fitness is not surprising, this study suggest that the longer intervals combined with high intensity continuous training can generate marked increases in biomechanical variables in almost all relatively young adults. The other studies performed 8-12 weeks of whole body RT at various exercise intensities and found that the frequency of training and the volume of work completed do not appear to play a significant role with observed following a whole body or a single exercise RT program, which can be expected to improve concurrently both muscular and cardiovascular finesses within a single mode of resistance training when young persons have initially low fitness levels (Ozaki et al., 2013). Additionally, performing resistance and aerobic training concurrently within the same day or a couple of days inhibits the developments of strength and muscle hypertrophy compared with resistance training alone (Docherty & Sporer, 2000). Although the biomechanical parameters of explosive force was continuing to increase at the end of 12 week training programs, the students declined to continue behind this period, due to the difficulty nature of this training. We believe that caution must be used in concluding that at least some humans maybe for genetic reasons incapable of increasing their peak maximal power in response to endurance training.
Based on the data obtained, we believe that TRT and HIRT exercise programs are very effective in increasing Pmax and efficiency and so in improving explosive force. However there are some limitations that need to be validated for the future research, which include other samples also in different disciplines as well as active or no active subjects, for this kind of training. So, it is important to involve other interests groups as comparative groups, so that the effectiveness of different exercise training program can be known. These findings suggest that the magnitude of the peak maximal power response to the two RT programs is adequate for improving explosive force.

Conclusions

In conclusion, the present study suggest that, the HIRT composed by functional training, fitness challenge and core & abdominal exercises have the most benefit form improving body composition, peak maximum power, efficiency and explosive force. In general, individuals who train by exercising for a long time will develop better muscle and endurance capacity, whereas those who work against a heavy load will get bigger and stronger muscles. However, recent work using TRT and HIRT exercises training program help to increase endurance and resistance from the classical view of training specificity. We believe that a combination of exercise and nutrition are required for the best results during these exercise training program applications. As a conclusion, the results taken from experimental and control group revealed that HIRT training programs in experimental groups was more efficient in terms of biomechanical variables, which as a result of training program, peak maximal power and efficiency was increased ($p < 0.001$). The estimated mean change in maximum power output and efficiency over the training program was 4.08 W/kg and 4.2% efficiency ($p < 0.05$) when compared the experimental group to control group. The results have verified that the high intensity resistance training is very effective and it is highly recommended to use widely for the other interests group or sports disciplines that not involve maintaining stable body position, but sports that require speed, agility and flexibility. The conclusions from the results of this study are: applying resistance training and strength exercises in Students of SUT was very effective in improving efficiency, and explosive force. We hope and believe that this study will help other researches to prove and to apply resistance training and strength exercises for improving explosive force in sport performance by involving other control group as comparison. In summary, this study indicates that in addition to studies using training programs consistent with curricular programs and behind of them, the basic biomechanics of trainability needs to evaluate using regimes which allow generating the most possible physiological adaptions.

Impact of the study

The results of this study serve to change the concept that force training after applying special training programs with traditional and high intensity strength exercises can improve performance levels. More studies are needed to investigate the validity of this method in resistance training.

Study limitations

However, there are some limitations, which need to be validated for the future researches. These limitations include: the size of the sample used, so it is necessary to involve a wider sample size, including subjects of different ages and weights, in order to see the results over a longer period of time and to reduce comparisons between them.

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Conflict of interest
The authors declare that there is no conflict of interest.

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