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Enhancement of Strength Training on Strength Power Endurance and Flexibility

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Abstract

The purpose of the current study was to investigate the effect of 12 weeks of strength training on abdominal strength, explosive power, aerobic endurance and lower back and hamstring flexibility of school children. Subjects for this study were 40 healthy male school children (age: 14 ± 1.5 years, height: 146 ± 5.8 cm, body mass: 47 ± 4.4 kg) The Forty subjects were randomly assigned in to two equal groups, STG- Strength training group (n=20) and CG- Control group (n=20). The training program's duration was 12 weeks, and it consisted of own body exercises on circuit based strength training sessions. Abdominal strength- Measured through sit ups test- sit-ups completed in the 30 seconds-Explosive Power- Standing Broad Jump test- Aerobic Endurance- The Cooper Test- test was used-Lower back and hamstring Flexibility – sit and reach test. The pre test and post test randomized control group design was used as an experimental design. Selected criterion variables was statistically analyzed with paired sample't' test was used to find out significant improvement and analysis of covariance (ANCOVA) was used for significant difference and all the cases 0.05 level of confidence was fixed to test the hypothesis. The Experimental group was produced favourable changes in abdominal strength, Explosive power, Aerobic endurance and lower back & hamstring flexibility due to that effect of 12 weeks of Strength exercise program of school children. The control group showed no significant change in any.

Keywords: Abdominal Strength, Lower Back, Flexibility, Hamstring.

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Introduction

Exercise and sports are an important part of childhood. The lessons learned from team and individual sports are applicable throughout life. Children who establish regular exercise habits will ideally continue them into adulthood. The Centres for Disease Control and Prevention and the American Academy of Paediatrics recommend that all school-aged children participate in at least 60 minutes of moderate to vigorous developmentally appropriate physical activity each day.(1) **S**trength can be defined as the ability to produce force. As force is a vector quantity, the display of strength will have a magnitude and direction. Strength can also be associated with a rate of production. Strength can be displayed isometrically or dynamically and depends on a number of factors such as the type of contraction, rate of motor unit activation, and degree of activation. Because power is the product of force and velocity, then alterations in force should affect changes in power production. (2, 3) During the last decade, strength training has proven to be a safe and effective method of conditioning in children, provided that appropriate exercise guidelines are followed. Reports indicate that regular participation in a youth strength training program may increase muscle strength and local muscular endurance, enhance bone mineral density, improve body composition, and reduce the risk of injuries in sports and recreational activities. (4, 5, 6, 14) Ramsay et al (1990) reported that two studies used the twitch interpolation technique to determine the effects of changes in motor unit activation on strength increases in preadolescent boys when in a proper training environment. This technique involves delivering single electrical pulses to a muscle when the subject is at rest and while the subject attempts to produce a maximum voluntary contraction. The training sessions lasted ten weeks; when it was over, they saw a gain of 9% in the boys' elbow flexors and 12% in their knee extensors. Strength gains were due to increased neuronal activation, intrinsic muscular adaptations, and motor coordination (learning). While muscle strength increased, the size of the muscle did not. (4) Strength training, or resistance training, is a form of physical conditioning used to increase the ability to resist force. By increasing muscle strength, strength training can improve sports performance in young athletes. Different types of exercises are used in strength training in young athletes, including weight machines, free weights, and exercises which use a body's own resistance. By using different combinations of exercise repetitions, ranging from one set of ten repetitions, to five sets of fifteen repetitions, young athletes can achieve increases in strength from 30-

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40% over an eight to twelve week training program.(12)

In fact, studies have revealed significant increases in muscle strength and mass in preadolescent boys and girls (Faigenbaum et al. 1993; Morris et al. 1997; Pikosky et al. 2002; Westcott et al. 1995). Furthermore, research has shown that these strength training effects are relatively long-lasting (Faigenbaum et al. 1996). Although some of the strength gains are due to motor learning, children add muscle tissue through increased protein synthesis, in much the same way that adults do. Again, contrary to popular opinion, strength training has been shown to *enhance bone development* in kids. In a 10-month study involving 9- and 10-year-old girls, bone mineral density increased by about 6.2 percent in those who performed both strength and aerobic exercise, compared to about 1.4 percent in those who did not strength train (Morris et al. 1977).(13,14,15,16, 17)Fiatarone et al. (1990) reported that eight weeks of resistance exercise for the legs improved strength and function in nonagenarians (mean age 90±1 yr). Quadriceps strength improved 174% and tandem gait speed increased 48% following resistance training. (19) According to Carroll et al, the physiological adaptations associated with resistance training can potentially produce either positive or negative transfer to sports performance. Negative transfer could occur if there is increased co activation of antagonist muscles because this would produce force that opposes the intended movement direction. (20)

Several studies have shown that strength or power measures are associated with endurance performance, For example: Among road cyclists anaerobic power was a major factor separating higher and lower rank athletes (Tanka et al. 1993). Anaerobic power has been shown to be a critical factor determining success among cross-country runners with similar a VO2max (Bulbubian et al. 1986). Additionally evidence indicates that distance runners with more powerful muscles are more likely to succeed (Nokes 1988). Several studies have shown strong correlations between swimming performance up to 400 m and maximum strength/power of the upper body (Costill, et al. 1980, Davis 1959, Hawley and Williams 1991, Sharp et al. 1982, Toussaint and Vervoorn. 1990). These data indicate the potential for strength training and increased maximum strength to enhance endurance. (21, 22, 23, 24,25,26,27, 28) Barbosa et al. have assessed the effects of 10-week strength training on the flexibility behaviour of sedentary elderly women, aged 62–73 years. Flexibility was evaluated by applying the Sit and Reach test before and after strength training. In conclusion, training has caused a significant flexibility increase, whereas no difference was found in the control group. (29)

More recently, strength training has been tested as a means to build muscle mass, strength and quality in healthy Individuals and those suffering from chronic conditions like diabetes. Muscle quality, defined as maximal force production per unit of muscle mass, may be a better indicator of muscle function than strength alone. (31, 32) **A** well-rounded program that contains activities to develop both strength and aerobic power is required to maximize physical fitness and health benefits. The inclusion of strength training in adult fitness maintenance of muscular strength and endurance (33, 34, and 35) as well as in improving body composition. (36, 37, 38) Strength training can also help maintain flexibility with exercises that use the full range of motion. (39)

The results of the aforementioned studies indicate that strength training can help the children to increase muscular strength, muscular endurance, bone mineral density and body mass and increase strength, endurance, range of motion at the joint and bone mass density in adult men and women cyclist. Information on the effect of strength training this study will give some additional knowledge on strength training for children. Therefore, the goal of the current study was to investigate the effect of 12-week, circuit-based strength training program on strength, power, endurance and flexibility among school children.

Methodology

Prior to a 12-week training program, subjects were randomly divided into 2 groups: a strength training group (STG) and a control group (CG). All subjects had performed no regular physical activity prior to this project's training program. Subjects assigned to the STG performed a 1-week model strength training program to get familiarization of the exercise and repetitions. Training period consisting of 3 sessions per week, during which the three different group of exercises (Session I, II, III) used in the training program were performed in a circuit based fashion for 2 sets of 6 to 8 repetitions, except for the abdominal exercise, which was performed for 2 sets of 10 to 12 repetitions each with recovery period of 2 min between repetition and 5 min between sets. No training was given to the control group. The training program's duration was 12 weeks, and it consisted of own body exercises on circuit based strength training sessions. Training frequency was 3 sessions per week, with at least 48 hours of rest between sessions. A total of 36 sessions were performed in the 12-week training period with sessions performed between 6 am to 9 am. Adherence to the program was 100% for all individuals in the STG. The own body strength training exercises mentioned in the table I.

Table I. Analysis of covariance of the data on resting heart rate of pre and post tests scores of low intensity, high intensity aerobic trainings and control groups.

12 weeks		
Session I	Session II	Session III
Forward lunge Clock lunge Curtsy lunge Body weight squat Lunge jump Squat reach jump Wall Sit	Inch worm Knee Tuck Jump Burbees Plank Step up Chair pose squat Mountain Climbers	Crunches Abdominal Flutter kicks Bicycle Crunches Sprinter Sit-ups Shoulder Bridge

The intensity of training was tapered so that fatigue would not be a factor during post-testing. Warm up prior the session ten minutes jogging - to increase body temperature, 10 to 15 minutes dynamic stretching exercises - reduce muscle stiffness, and cooling down ten minutes jogging/walking - decrease body temperature and remove waste products from the working muscles.5 to 10 minutes static stretching exercises was strictly followed by the researcher. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise.

Subjects for this study were 40 healthy male school children (age: 14 ± 1.5 years, height: 146 ± 5.8 cm, body mass: 47 ± 4.4 kg) not involving in any regular physical activity before this experiment was selected from the Government Higher Secondary School, Thuvarankurichy, Trichy District at randomly. The Forty subjects were randomly assigned in to two equal groups, STG- Strength training group (n=20) and CG- Control group (n=20). Immediately after the end of the training session the next day the experimental variables was measured by the researcher with the assistant. Some observers believe that 1 repetition maximum (1RM) testing (the maximal amount of weight that can be lifted at one time through a subject's complete range of motion) is inappropriate for children, and others are concerned that this method of testing may cause structural damage to the developing musculoskeletal system of young weight trainers. Attitudes associated with strength-testing children were highlighted in a recent National Strength and Conditioning Association (NSCA) internet survey, which found that 2,043 of 2,311 responders (88%) believe that 1RM strength testing is inappropriate for children. Strength and power production in sport are influenced by a range of neuromuscular factors. In simple terms, muscle performance is determined by a combination of muscle cross-sectional area and the extent to which the muscle mass is activated, that is, neural factors. (7, 8,9,10, 11) According to the statement mentioned above, for this current only the field treatments and tests are used to assess all the experimental variables which are applied. Abdominal strength- Measured through sit ups test- the number of correct sit-ups completed in the 30 seconds and uses this recorded value to assess.(42) Explosive Power- Standing Broad Jump test – subject places their feet over the edge of the sandpit, crouches down and using the arms and legs jumps horizontally as far as possible landing with both feet into the sandpit, measures and records the distance from the edge of the sandpit to the nearest impression made by the athlete in the sand pit, repeats the test 3 times, the longest recorded distance to asses.(40,41) Aerobic Endurance- The Cooper Test- test requires the athlete to run as far as possible in 12 minutes. Distance covered from the start to the end of the 12 minute was used to assess the performance of the subject.(43) Lower Back & hamstring Flexibility- subject sits on the floor with their legs fully extended with the bottom of their bare feet against the box and places hands on top of the front edge of the box in front of ruler, slowly bends forward and reaches along the top of the ruler as far as possible holding the stretch for two seconds, records the distance reached by the subject finger tips (cm), performs the test three times, calculates and records the average of the three distances and uses this value to assess.(42)

The pre test and post test randomized control group design was used as an experimental design. The collected data from the two groups prior to and immediately after the training programme on selected criterion variables was statistically analyzed with paired sample't' test was used to find out significant improvement and analysis of covariance (ANCOVA) was used to find out the significant difference among experimental and control groups. In all the cases 0.05 level of confidence was fixed to test the hypothesis.

Results

Before training, no significance was shown between the means of both groups on abdominal strength, Explosive Power, Aerobic Endurance and Lower back & Hamstring Flexibility test.

After 12 Weeks of training Significant Improvement Gains in All Tests Shown by the STG Pre – to Post Training result (Table 2), Whereas CG showed no significant changes, the obtained't' ratio value of experimental groups on abdominal strength, Explosive Power, Aerobic Endurance and lower back & hamstring flexibility Are 4.95*, 7.6*, 9.88*and 22.43*which are higher than the table value of 2.09 with df 19 at 0.05 level of significance. And Significant difference Where shown Between STG and CG (Table 3) the obtained F-ratio of abdominal strength, Explosive Power, Aerobic Endurance and lower back & hamstring flexibility for adjusted post test means were 53.47*, 50.54*, 65.39*and 493.42* respectively which are more than the table value of 4.11 for df 1 and 37 required for significant at .05 level of confidence. So The result indicate that there was a significant improvement between pre and post test means of experimental group and significant difference between experimental and control groups and there was no change found on control group. This study indicates that strength training for children would supported for the development of the above mentioned experimental variables.

Table II. Computation of Mean, SD and 'T' Ratio

Criterion Variables	Group	test	Mean	SD	t'- Ratio
Strength	Training	Pre test	13.75	1.9702	4.95*
		Post test	17	4.2734	
	Control	Pre test	13.7	2.059	1.37
		Post test	13.8	1.9628	
Power	Training	Pre test	1.5635	0.020072	7.6*
		Post test	1.7195	0.090929	
	Control	Pre test	1.56	0.03447	1.86
		Post test	1.57	0.033166	
Endurance	Training	Pre test	2221	71.7378	9.88*
		Post test	2378.5	51.6338	
	Control	Pre test	2185.5	61.5993	0.39
		Post test	2191	90.4899	
Flexibility	Training	Pre test	4.33	0.3097	22.43*
		Post test	7.495	0.5472	
	Control	Pre test	4.445	0.2892	0.65
		Post test	4.46	0.3283	

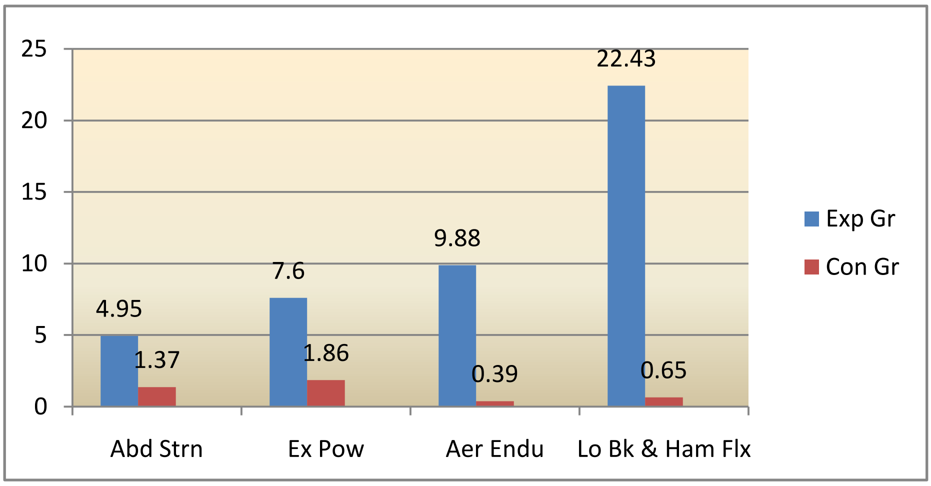
Significant at 0.05 levels. Degrees of freedom n-1=19 is 2.09.

Table III. Analysis of covariance on criterion variables of experimental groups

Criterion Variables	Adjusted post test means		Source of variance	Sum of Squares	df	Mean Squares	'F'- Ratio
	Training group	Control group					
Strength	16.96	13.84	B	97.36	1	97.36	53.47*
			W	67.37	37	1.82	
Power	1.72	1.57	B	0.22	1	0.22	50.54*
			W	0.16	37	0.001	
Endurance	2367.9	2201.6	B	257474.1	1	257474.1	65.39*
			W	145684.5	37	3937.42	
Flexibility	7.52	4.43	B	92.03	1	92.03	493.42*
			W	6.9	37	0.19	

*Significant at 0.05 level of confidence.
(The table value required for significance at 0.05 levels with df 1 and 37is 4.11).

Figure I. Shows that the 't' value significant improvement of Exp and Con gr due to the effect of 12 week of strength training.



Discussion

The aim of this study was to asses 12 week of strength training on strength, power, endurance and flexibility of school children. Related literatures done under this study reveals that, according to Fiatarone et al. (1994) examined the effect of 10 weeks of resistance exercise for the legs only on muscle strength and function in elderly adults (mean age, 87± 0.6 yr). Resistance exercise increased muscle strength (113%), gait velocity (12%), stair climbing power (28%). (18) Strength training has also been shown to have beneficial effects on endurance factors associated with road cyclists. Bastiaans et al. (2001), using 14 male competitive road cyclists, investigated the effects of explosive strength training on endurance related factors. As with Paavolainen et al. (1999) endurance training time was replaced with strength training (37% of total time) so that the total approximate training time was equal between experimental (GpE, n =6) and control (GpC, n = 8) groups. While the addition of strength training resulted in small increases in power output and riding efficiency the major effect dealt with "short-term performance". Short-term performance was measured by calculating mean power output at a fixed pedal rate (60 RPM) during a 30 s ergo meter test. It was shown that GpC lost mean Power and GpE showed small increases over the 9 week period. (30) The finding that strength training may increase a joint's range of motion in middle-aged women is in agreement with previous studies performed with older adults demonstrating that strength training does increase flexibility (29, 44).The above literatures mentioned that the strength training improves strength, endurance, power and flexibility at various levels. In this current study strength training protocol indicate a positive change of improvement on experimental variables of school children.

Conclusion

On the basis of the findings it was concluded that 12 weeks of Strength exercise program produced favourable changes in abdominal strength, Explosive power, Aerobic endurance and lower back & hamstring flexibility of school children. Strength training for children can be safe and effective when proper safety guidelines are met and each child's program is designed appropriately and individually. "Adding strength training to a program of regular physical activity will help to decrease the risk of chronic diseases while improving quality of life and functionally, allowing people of all ages to improve and maintain their health and independent lifestyle."

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