Research Journal of Physical Education Sciences _____ ISSN 2320–9011
Vol. **5(1),** 1-7, January **(2017)** *Res. J. Physical Education Sci.*

Effects of strength training on endurance parameters and performance among under-19 provincial endurance athletes

K. Kuganesan[1*] and Bhavani Ahilan[2]
[1]Jaffna Central College, Jaffna, Sri Lanka
[2]Sport Science Unit, University of Jaffna, Sri Lanka
gugan125@gmail.com

Available online at: www.isca.in, www.isca.me
Received 19th December 2016, revised 20th January 2017, accepted 22nd January 2017

Abstract

Purpose of the study was to examine the effect of strength training on endurance parameters and performance among under-19 provincial endurance athletes. To achieve this, the present study ninety(N=90) endurance athletes from 800M, 1500M and 5000M events in Northern Province in Sri Lanka has been assigned. Thirty (n=30) subjects have been selected from each event (800M, n=30), (1500M, n=30), (5000M, n=30). The strength training was carried out for period of 12 weeks to assess the effect of training packages on body mass index (BMI), VO_2max, muscular strength (MS), muscular endurance (ME) and endurance performance. Pre test and post test data were collected from selected variables before the intervention and after intervention. T test was administered to find out significant difference between pre test and post test. Further one way analysis of variances (ANOVA) was done to find out significant differences of variables among the above three events athletes. Result revealed that strength training did not show significant differences on the intervention of VO_2max in T test. Moreover F ratio did not show significant differences on BMI (post intervention) and ME (baseline study) among three events athletes. Finding revealed that strength training has improved MS, ME, BMI and endurance performance of 800M and 1500M athletes. However Strength training did not improve endurance performance of 5000M athletes.

Keywords: BMI, VO_2max, Muscular Strength, Muscular Endurance, Performance.

Introduction

Strength training is a muscular exercise performed against external force. It is commonly practiced among endurance athletes to increase muscles strength, type II muscles fibers, anaerobic energy system, muscles contractile and muscles endurance. Further it reportedly increases the cross-sectional area of muscle fibers, muscle function[1] and type II (fast twist fiber) muscles fibers which may enhance the running economy, improving running economy demand low energy expenditure during endurance training. Therefore it requires minimum level of oxygen.

Endurance performance depends on three major factors such as running economy, maximal oxygen consumption and lactate threshold[2-4]. Previous research studies indicate that strength training enhances the running economy of endurance athletes through neurological and muscular changes. This muscular adaptation may increase the force production, intramuscular glycogen or shifts within major fiber type group[6-8]. These improvements may enable athletes to increase the attacks and sprint in the final minutes of endurance events. Middle distance running is dependent on aerobic and anaerobic energy supply that strength training increases the anaerobic energy distribution. These energy pathways help to increase the running economy and intensity of running. Another study has shown that running economy influenced on performance of well trained distance runners[9]. Enhancing the running economy would increase the speed over distance.

VO_2max is an important parameter to determine aerobic capacity of endurance athletes. It plays a key role in achieving success in endurance sports[10-12]. Maximum oxygen uptake of elite male middle and long distance runners are more than 85 ml x kg-1 x min-1[13] and best endurance performance athletes demand peak VO_2max values[10,11,14]. VO_2 max and endurance performance are having interrelationship it is confirmed in previous studies which have ensured that strong correlation is between VO_2max and middle (800m, r = 0.75) and long distance (marathon, r=0.78) runners performance among heterogeneous group[14,15]. Increasing VO_2max level may increase the activity of mitochondrial density, connective tissues, oxidative enzymes, type I muscles fibers and capillary density. These factors enhance endurance capacity, therefore VO_2max may be improved but strength training affects those factors (mitochondrial density, connective tissues, oxidative enzymes, type I muscles fibers and capillary density) and few studies conducted on the effect of strength training on VO_2max revealed that strength training had neither negative or positive impact on VO_2max.

Body mass index is important variable that assess the body fat proportion. Endurance athlete's body fat may be lower than other sports because fat proportion plays an important role in

endurance performance, therefore all endurance athletes give preference to decrease fat proportion up to 15%. Some study had showed that weight training had positive effect on decreasing body fat percentage, fat weight and body weight[16]. It may assist to build up the fat free mass and bone minerals status[17,18]. Changing neurological and morphological components from strength training which positively changed in body composition[19]. Another study proved that improving the fitness components, muscular strength, size, fat free mass and decreased body fat have positive effect on athletic performance[20]. Strength training develops the fat free mass and decrease the body fat[16,18,21,22].

To our knowledge previous strength training has assessed the effect of training on other variables which may not determine the endurance performance and several previous studies have not efficiently clarified on selected endurance variables. These endurance variables determine the endurance performance. Therefore present study examines the effect of strength training on endurance parameters and performance among under-19 provincial endurance athletes. We hypothesized that strength training would enhance endurance performance of all group of endurance athletes.

Materials and methods

Participants: Trained under 19 schools Northern Provincial endurance athletes were recruited for this study from 800M, 1500M and 5000M events. All the participants answered a questionnaire, regarding the information about personal data, sports participation, and medical history. Based on that, 95 endurance athletes volunteered to participate in this study, but 5 of them left from this study due to injury and off season. Recruited subjects had completed a preliminary medical history, exercise questionnaire and written informed consent from participants. After the medical screening, each potential subjects were examined by physician specialized in family practice and sports medicine, and a completed medical history was obtained prior to participation. Finally ninety (N=90) under-19 Provincial endurance male athletes were chosen for this study. They underwent strength training period of 12 weeks.

Strength training protocol: Pilot study was conducted among the selected endurance athletes to assess the ability of strength. Based on the performance of subjects the strength training was provided to athletes. Before proceeding with this training, sufficient instructions were given to subjects about type of training, duration of training, nutrient intake. Training was divided into two part such as upper body training (Bench press, Push jerk, Back extension) and lower body training (leg press, leg curl, squat). Upper body and lower body strength training followed in different day of week. This training was performed for 2 days (Tuesday and Friday) in a week. Training lasted 4 weeks without modification of weight, but after 4 weeks the weight was increased to all subjects with similar plan until 12 weeks. It is shown in the Table-5.

Measurement of Body Mass Index (BMI): BMI is calculated from weight (W) and height (H). BMI=W/(H×H), where: W refer body mass in kilograms and H= height in meter. Calculated BMI was recorded in kg/m^2. Higher score usually indicates the higher levels of body fat.

Measurement of VO_2 Max: The objective of the Bruce treadmill test is to monitor the development of the endurance (VO_2 max). To undertake this test required resources are treadmill, stopwatch, and assistant. The subjects had warm up about 10 minutes. The assistant sets the treadmill up with a speed of 2.74km/hr and an incline of 10% (stage1). Treadmill speed and incline are increased every three minutes (Table-2) When the command GO was given stopwatch was pressed and then subject started test. Besides the assistant, at the appropriate times during the test, adjusts the treadmill speed and slope as per the Table-2 (E.g. after 3minutes the speed is adjusted to 4.02 km/hr and slope to 12% and soon (Table-2). The stopped was stopped when subject could not continue and recorded time (T-total time in minutes). From the total running time an estimate of the subjects VO_2max can be calculated as follows: $VO_2max=14.8-(1.379\times T)+(0.451\times T^2)-(0.012\times T^3)$. T- Total time in minutes.

Measurement of muscular endurance: Athletes touch the floor with the hands and toes. When they do this, the body and legs should be straight line, feet slight apart, arms at the width apart extended and right angels to the body. Knees and back should be straight. The subjects lower the body to a predetermined point, to touch some other object, or until there is a 90-degree angle at the elbow, then return back to the starting position with the arms extended. This action is repeated until exhaustion. Subjects followed rhythm. Correctly performed push up was recorded.

Measurement of muscular strength: The 1RM squat was administrated to measure the lower limb of muscular strength. According to Baeshle et al. 1RM was determined as maximal amount that a participant could lift successfully only once. Prior to the 1RM, warm up comprising of an initial set of five lift sets with low resistance was performed before increasing the weight for one set of three lifts. After a self selected rest period, subjects began to complete their one repetition sets. The first lift was performed at an estimated resistance that would enable the completion of only one lift. Following each successfully lift, additional resistance was added until the subjects 1RM was determined. The 1RM was always completed within five attempts in accordance with previous recommendation. All the 1RM measurements were recorded in kilograms for data analysis.

Statistical analysis: All the value of selected parameters was expressed as mean and standard deviation. T test was used to find out significant differences between pre test and post test of all the variables of intervention. Further one way analysis of variance (ANOVA) was administered among group to find out

the significant differences. In each case the significant level was chosen at 0.05 levels. All the data was interpreted by using Minitab-16 version of statistical software.

Table-1: 800M Athletes Selected Variables Descriptive Static and P values

Variables	Test Level	Mean ± S.D	P value
BMI	Pretest	22.98±1.41	0.000
	posttest	20.24±2.79	
VO_2max	pretest	45.33±2.51	0.815
	posttest	45.53±3.94	
M.E	pretest	39.23±4.74	0.000
	posttest	43.53±4.61	
M.S	pretest	42.47±5.44	0.004
	posttest	46.57±5.24	
Performance	Pretest	130±8.33	0.000
	posttest	122.80±5.86	

Results and discussion

BMI level was significantly dropped after the intervention which can be observed in Table-1, 2 and 3, baseline data also has shown significant difference among three events of athletes on other hand that after intervention of this three events of athletes BMI level was not significant differences which is shown in Table-4.

VO_2 max was not significant improvement on post intervention among 800M, 1500M and 5000M athletes according to Table-1, 2 and 3 but significant differences could be observed among three difference events athletes on baseline and intervention study which is presented in Table-4.

Muscular endurance was improved in all events of intervention. Which shows significant differences in Table-1, 2 and 3. F value ($P<0.05$) of Intervention study showed significant difference in muscular endurance among 800M, 1500M and 5000M athletes but baseline study does not show significant difference among three events of athletes which is shown in Table-4.

Muscular strength showed significant difference between pre test and post test. After the intervention the muscular strength has increased in all the events of athletes which is presented in Table-1, 2 and 3. Further F test value ($P<0.05$) presented in Table-4 which shows significant differences in baseline and after intervention study.

Performance of 800M and 1500M athletes revealed a significant improvement which is shown in Table-1 and 2 but there was not a significant of improvement in after intervention of study in 5000M athletes' performance. It was presented in Table-3.

Table-2: 1500M Athletes Selected Variables Descriptive Static and P values

Variables		Mean ± S.D	P value
BMI	Pretest	21.99±0.98	0.000
	posttest	19.98±1.51	
VO_2max	pretest	52.07±3.16	0.621
	posttest	51.70±2.51	
M.E	pretest	40.93±4.58	0.000
	posttest	46.33±4.00	
M.S	pretest	37.53±3.34	0.000
	posttest	44.33±3.48	
Performance	Pretest	265±13.2	0.002
	posttest	253.6±14.5	

Table-3: 5000M Athletes Selected Variables Descriptive Static and P values

Variables		Mean ± S.D	P value
BMI	Pretest	22.18±1.88	0.000
	posttest	19.55±1.86	
VO_2max	pretest	57.10±4.04	0.642
	posttest	56.53±5.28	
M.E	pretest	41.27±3.72	0.001
	posttest	49.47±4.11	
M.S	pretest	38.30±4.08	0.000
	posttest	43.53±3.16	
Performance	Pretest	1018±166	0.084
	Posttest	962.1±36.5	

Table-4: 800M, 1500M and 5000M Athletes Selected Variables Descriptive Static, F ratio and P values

		Baseline value	Post value	Baseline value		Post test value	
Variables	Events	Mean±S.D	Mean±S.D	F value	P value	F value	P value
BMI	800M	22.98±1.41	20.23±2.78	3.83	0.025	0.80	0.451
	1500M	21.99±0.98	19.98±1.51				
	5000M	22.17±1.88	19.55±1.85				
VO_2max	800M	45.33±2.51	45.53±3.93	96.24	0.000	55.05	0.000
	1500M	52.06±3.16	51.70±2.50				
	5000M	57.10±4.03	56.53±5.28				
M.E	800M	39.23±4.73	43.53±4.61	1.87	0.160	14.63	0.000
	1500M	40.93±4.57	46.33±4.00				
	5000M	41.26±3.72	49.46±4.10				
M.S	800M	42.46±5.44	46.56±5.23	11.05	0.000	4.49	0.014
	1500M	37.53±3.34	44.33±3.47				
	5000M	38.30±4.07	43.53±3.15				

Table-5: Strength Training scheduled for 12 weeks

Type of Exercise	1 W S×R	2W S×R	3W S×R	4W S×R	5W S×R	6W S×R	7W S×R	8W S×R	9W S×R	10 W S×R	11W S×R	12 W S×R
Leg Curl	2×8	2×6	2×9	2×10	2×8	2×10	2×12	3×10	3×8	4×8	4×6	4×5
Push jerk	2×6	2×5	2×7	2×8	2×6	2×8	2×10	3×8	3×7	4×7	4×6	4×5
Leg press	2×6	2×5	2×8	2×9	3×5	3×6	3×8	4×7	4×6	4×9	4×6	4×6
Back extension	3×10	3×8	3×12	3×14	3×12	3×14	3×12	3×16	3×14	3×15	4×10	3×8
Squat	3×5	3×4	3×7	3×8	3×6	3×8	3×10	4×8	4×7	5×7	5×6	5×5
Bench press	2×6	2×5	2×8	2×9	2×8	2×9	2×12	3×9	3×8	4×7	4×6	4×5

W-weeks, S- sets, R-repetition

Discussion: Endurance athletes traditionally followed cardiovascular training. Which increase the aerobic capacity and aerobic metabolism to act prolong period. But Regular endurance and cardiovascular training have not shown positive impact on progress of endurance performance in previous studies therefore researchers have recommended that alternative and positive training for endurance athletes. In this connection strength training was introduced in 1950 to improve athletic performance. Initially strength training was recommended to anaerobic sports. But some previous studies proved that strength training is important for endurance athletes[24]. Besides strength training improved anaerobic potentials which also have significantly impacted endurance performance however conflict results arrived at several studies that showed strength training has negative impact on endurance performance.

However present study did not find any negative impact on endurance performance. But strength training neither negative or positive impact on endurance performance. It was ensured in present study of 5000M endurance athlete's performance even enhanced muscular strength, muscular endurance and BMI. On other hand strength training may enhance the running economy which led to peak endurance performance. It was confirmed in present study of 800M and 1500M athletes' performance. Moreover strength training improves the anaerobic capacity that determines the endurance performance among well trained athletes. Besides strength training increases running performance through neurological and muscular changes[6-8]. Positive muscular adaptation may enhance anaerobic enzyme activity, increased force production, increase intramuscular glycogen and type II muscles fiber (fast twist fiber). This may help to increase the running economy and intensity of training. Running economy has been shown to influence performance for well trained endurance runners[9].

Many strength condition researchers had focus on developing muscular strength because it enhances running economy. Enhancing the running economy would increase the speed over a distance and decrease oxygen consumption[25]. Therefore the researcher has found that strong correlation exist between VO_2max and middle and long distance of performance among heterogeneous[14,15]. Maximum oxygen uptakes and physiological determinants have been well documented in endurance performance[26]. Thus VO_2max protocol has been used in laboratory to monitor and predict the performance of middle and long distance runners. However this study that show weak relationship between VO_2max and performance because elite international endurance athletes VO_2max is more than 80 (mL/kg/min) but present study endurance athletes VO_2max are less than 60 (mL/kg/min). It shows that strength training does not make significant improvement or changes on VO_2max. It was confirmed in previous study also which highlighted that strength training has neither a negative nor positive impact on VO_2max[27,28].

Muscular endurance is one of the important variables for endurance athletes because which demands frequent of contraction for long period of time without fatigue. It may enhance endurance performance but it is unclear in this study because previous studies have not supported that muscular endurance improved the endurance performance. However muscular endurance may limit the endurance performance because muscles involve number of repetition contraction for particular period. Moreover previous studies never analyzed the role of muscular endurance in endurance performance. Although present study found that Strength training improves the muscular endurance.

Strength training is considered as important training for endurance athletes because which increase the force production of muscles, anaerobic energy supply, cross-sectional area of muscles fibers, strengthens the muscles tissues[6-8] and prevents from injury. Increasing those factors is highly associated with running economy. Running economy is crucial variable to improve the running performance of endurance athletes. Recent study[28,29], which supports to present study that endurance running performance has been examined in a number of studies with the majority reporting running performance improved through strength training. Strength training has been associated with interfering or inhibiting endurance developments[30,31] but

strength training has produced negative impact on some endurance factors like number of mitochondrial, connective tissue, type I muscles fibers[32]. These factors are associated with endurance capacity. Some researchers stated that in their study light or low weight resistance training increases the muscles mass which is negative factor for endurance performance. Body mass is an important determinants of performance in running[23] but resistance type of training gained muscles strength and burned the fat percentage. It could be observed in the present study which shows significant level of fat reduction and muscular strength gained in the intervention of strength training. Strength training increases the lean body mass tissues which is positively and highly correlated with endurance capacity and VO_2max[30] previous studies found the effects of five weight training and circuit training on body composition. The studies showed a mean decrease in body weight of o.12kg, increase in lean body mass of 1.5kg and decrease in fat mass of 1.7kg.

Conclusion

Strength training had positive impact on intensive events like 100M, 200M and 400M athletes without controversial because strength training improved the all the speed variables such as cross sectional area of muscles, type II muscles fiber, anaerobic energy pathway, muscular strength and muscles tone but improving speed variables may have negative impact on endurance factors such as mitochondria, connective tissue and type I muscles fiber. However present study arrives at conclusion that strength training had positive impact on muscles strength, muscular endurance, performance and body mass index of 800M and 1500M athletes it confirm that improved variables are associated with improvement of performance but strength training has not impacted neither positive or negative on VO_2max. It express that endurance performance not only depends on VO_2max but also depend on the muscular strength, muscular endurance and body mass index however the strength training have not positively impacted performance of 5000M athletes, even improved the muscular strength, muscular endurance and body mass index because distance athlete's endurance performance depends on aerobic metabolism [24]

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