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A Comparison of Endurance Training Responses to Hill and Sand among School Football Players

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Abstract

This present study compared the effects of 12 week endurance training responses to hill and sand surfaces on elastic leg strength and aerobic endurance (VO_2 Max) among school football players. Thirty six trained football players (age 14 – 17 years, height 149 - 168 cm, weight 50 – 65 kg) volunteered for the present study. They were randomly assigned in to three equal groups, HSG - hill surface group (n=12) SSG-Sand surface group (n=12) and CG- Control group (n=12). Leg Strength test, Balke VO2max Test were measured pre and post training. Paired t-test, ANCOVA and Scheffe's test were used to evaluate the effect of training. In all the cases 0.05 level of confidence was fixed to test the hypothesis. The result indicates that there was a significant improvement between pre and post test means of HSG and SSG and significant difference between experimental and control groups. When compare the two experimental groups, from the results it was found that the HSG was better than SSG on VO_2 Max and SSG was better than HSG on elastic leg strength. This study shows that a 12 week endurance training program on hill and sand surfaces may result in the most physical and physiological changes in young football players.

Keywords: Elastic Leg Strength, Vo2 Max, Endurance Running, Different Surfaces.

Introduction

Endurance can be defined as the capacity to sustain a given velocity or power output for the longest possible time. Performance in endurance events is heavily dependent upon the aerobic re-synthesis of ATP; this requires an adequate delivery of oxygen from the atmosphere to Cytochrome Oxidase in the mitochondrial electron transport chain and the supply of fuels in the form of carbohydrates and lipids. (30, 31) Endurance training causes adaptations in the pulmonary, cardiovascular and neuromuscular systems that improve the mitochondria and enhance the control of metabolism within the muscle cells. These adaptations shift the velocity- time curve to the right and therefore result in improved endurance exercise performance by Whipp et al. (32) Endurance training is quite a broad sweeping term. It's often used interchangeably with terms like "aerobic", "anaerobic", "strength" and "speed". (2) Endurance training has been a topic of study for many years. The ability to enhance aerobic performance over a short-term training program is often needed in pre-season programs. Recent research has been concentrated on different dimensions of endurance training. Especially considered in the development of aerobic endurance has been the role of the training surface. In recent decades many studies were done on deep water running, shallow water running, treadmill running, road running and stair running. (1) Different surface properties have different effects on the dynamics and mechanics of movement and also affect the energetic of running. They also found that the metabolic rate on various surfaces is positively related to surface stiffness. (21, 22).

The characteristics of a sand training surface and a hill training surface are quite different. Sand is an amazing, organic training surface that allows one to perform extremely powerful movements with minimal joint impact. Sand also drives athletes to test the limits of their anaerobic thresholds. Running and jumping activities done on sand get results faster than the same activities on any other surface. (19) In hill running, the athlete is using their body weight as a resistance to push against, so the driving muscles from which their leg power is derived have to work harder. The technique to aim for is a "bouncy" style where the athlete has a good knee lift and maximum range of movement in the ankle. They should aim to drive hard, pushing upwards with their toes, flexing their ankle as much as possible, landing on the front part of the foot and then letting the heel come down below the level of the toes as the weight

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is taken. This stretches the calf muscles upwards and downwards as much as possible and applies resistance which overtime will improve their power and elasticity. The athlete should look straight ahead, as they run (not at their feet) and ensure their neck, shoulders and arms are free of tension. Many experts believe that the "bouncy" action is more important than the speed at which the athlete runs up the hills. (20)

Sand surfaces are a popular alternative training venue for a range of firm ground sports (i.e., team sports, distance runners, etc), with research showing that there are distinct physiological and biomechanical differences associated with exercise on such training surfaces (4, 5–7, 8). Hill running has a strengthening effect as well as boosting your athlete's power and is ideal for those athletes who depend on high running speeds - football, rugby, basketball, cricket players and even runners. (9) VO_2Max, Which reflects an individual's maximal rate of aerobic energy expenditure, has long been associated with success in endurance sports.(33,34) Endurance-running events are strongly related to physiological determinants such as maximal aerobic capacity (V_ O2max), running economy (RE), and the exercise intensity at which a high fraction of the V_O2max can be sustained (3) VO2 max has been defined as: "the highest rate of oxygen consumption attainable during maximal or exhaustive exercise" (12).It's difficult to talk about endurance performance and endurance training without mentioning VO2 max or maximal oxygen uptake. Elite endurance athletes typically have a high VO2 max and for the most part it seems to be genetically determined (10). However, in untrained individuals VO2 max can be improved by as much as 20% (11). A goal of any endurance training program is to help the athlete reach their genetic upper limit for aerobic power.

Levine and Stray-Gundersen (13) studied the effect of living high and training low on endurance performance. A group of 39 middle-distance runners were split into three altitude training groups - a "live high - train low" group, a "live high - train high" group and a "live low - train low" control group. Unlike the control group, both "live high" groups increased their VO2 max on a return to sea-level by 5%. This was in direct proportion to the increase in red cell mass volume. However, only the "live high - train low" group improved their endurance performance as measured by a 5km time trial. Velocity at VO2 max and maximal steady state also improved in this group helping to shave an average of 13.4 seconds off their time. The same researchers carried out a further altitude training study on elite male and female runners and found similar performance enhancing effects of living high and training low (14). The athletes' 3km time was measured before and after a period of 27 days living at altitude (2500m, 8200ft) interspersed with training sessions at sea-level. VO2 max increased an average of 3.2% and performance by an average of 1.1%. While this may seem like a negligible improvement, 1.1% at an elite level translates into a significant performance advantage. Further altitude training studies, both at real altitude and simulated altitude, have shown that living high and training low can improve running economy (15), 800m, 1500m 3km performance (16), 400m performance (17,18). The studies that investigated running on different surfaces were carried out by other authors on recreational samples (23,24,22) and samples consisting of athletes (25,26,27) and very rarely on samples including school-age participants. However, the studies which focus on gender differences appear to be lacking. Some studies investigated the effect of training on different running surfaces on the performance of athletes. To assess the effect of training on different running surfaces they used the calf and thigh circumference of athletes, and their running performance (28). The greatest physiological and performance changes were found after a 6-week sand running program, which was expected because it is the most intense and demanding surface.

Research Studies reveal that endurance training response to sand and hill on strength and endurance among school level sports person has very limited literature. With this in mind, the aim of this present study compared the effects of the 12week endurance training responses to hill and sand surfaces on elastic leg strength and aerobic endurance (VO_2 Max) among school football players. It is hypothesized that endurance training responses to hill and sand will produce greater improvements on elastic leg strength and VO_2 Max over the 12-week, 36-session endurance training program.

Methodology

Thirty six trained football players (age 14 – 17 years, height 149 - 168 cm, weight 50 – 65 kg) volunteered for the present study. Subjects were selected from the Government Higher Secondary School, Thuvarankurichy, Trichy District at randomly. All players had experience with hill training and sand running during the previous season. Players were not involved in any formal training or individual training for at least 3 months prior to the start of this study. They were instructed not to engage in any additional exercise programs which might have confounded the experimental manipulation of the study. The Thirty six subjects were randomly assigned in to three equal groups, HSG - hill surface group (n=12) SSG-Sand surface group (n=12) and CG- Control group (n=12).

Prior to and following a 12-week endurance training program, all subjects completed the tests listed below. Elastic Leg strength - Leg Strength test- test requires the athlete to hop 25 metres as fast as possible-using legs alternatively first using right leg and repeats the test hopping on the left leg- records the average of the two recorded times - uses this value to assess Leg Strength.VO2 max can be determined through a number of physical evaluations. These tests can be direct or indirect**.** Indirect testing is much more widely used by coaches as it requires little or no expensive equipment. There are many indirect tests used to estimate VO2 max.

One of the most common is the Balke VO2max Test-The objective of this test is to monitor the development of the athlete's general endurance (VO2max) - test requires the athlete to run as far as possible in 15 minutes- records the total distance achieved in 15 minutes to the nearest 10 metres- The formula (Horwill 1992) used to calculate VO_2 max is (Total distance covered ÷ 15) - 133) × 0.172) + 33.3.The above mentioned test was conducted in two consecutive days of before and after 12 weeks of training program. Day 1- 25 mts hopping- was conducted for elastic leg strength and Day 2- Balke VO_2 Max test- was conducted for aerobic capacity (VO_2 Max).

Following the initial pre-test both hill surface training groups and sand surface training group (HSG & SSG) engaged in 12 week endurance training program. Training involved three 1 hour session per week, consisting of 3 sessions on the group specific training surface (hill & sand) over the period of 12 weeks and control group was not attended any training. The intensity and volume of training was tapered so that fatigue would not be a factor during post-testing. The endurance training program for both surfaces mentioned in the table I. All the training session were observed by the researcher.

The pre test and post test randomized control group design was used as an experimental design. The collected data from the three groups prior to and immediately after the training program 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. Whenever the ‘F’ ratio for adjusted post test means was found to be significant, the Scheffe’s test was applied as post-hoc test to find out paired mean difference was significant. In all the cases 0.05 level of confidence was fixed to test the hypothesis.

Table I. Endurance training protocol for both surface groups

Hill training Group	**Intensity followed for the training period of**
✓ 3 km jogging, ✓ 1200(2×2) 6 min rest between all race ✓ 180 mts (6×6)Walk back/ 5 min between set ✓ 100,150,200,250,300,350,400(1×3)In between race 50 mts walk forward,5 min rest between set ✓ 5 km running (45 min duration) ✓ High knee action 60 mts, Forward jog 60 mts, Sideward run 60 mts both side, 60 mts race (3 × 2) In between 5 min rest.	➢ Week 1 to 4 – 30 to 40 % of intensity was followed. ➢ Week 5 to 8 – 40 to 50 % of intensity was followed. ➢ Week 9 to 12 – 50 to 60 % of intensity was followed.
Sand training group	**Intensity followed for the training period of**
✓ 3 km jogging, ✓ 600 (2×2) 6 min rest between all race ✓ 120 mts (6×6)Walk back / 5 min between set ✓ 50,100,150,200,250,300,300,250,200,150,100,50 (1×3)In between race 50 mts walk forward,5 min rest between set ✓ 5 km running (50 min duration) ✓ High knee action 40 mts, Forward jog 40 mts, side ward 40 both side, race 40 mts.(3 × 3)) In between 5 min rest.	➢ Week 1 to 4 – 30 to 40 % of intensity was followed. ➢ Week 5 to 8 – 40 to 50 % of intensity was followed. ➢ Week 9 to 12 – 50 to 60 % of intensity was followed.

Analysis of data

Before training, no significance was found between the means of both training group on elastic leg strength and VO_2 Max. After 12 Weeks of training Significant Improvement Gains in All Tests Shown by the HSG and SSG Pre – to Post Training mean and SD are mentioned in the (Table 2), Whereas CG showed no significant changes, the obtained’t’ ratio value of experimental groups on Elastic leg strength and VO_2 Max Are 3.94*, 5.56*, 14.1*, and 10.69* which are higher than the table value of 2.20 with df 11 at 0.05 level of significance.

Figure I. The pictorial representation of pre training and post training mean improvement of experimental and control groups on Elastic leg strength in seconds.

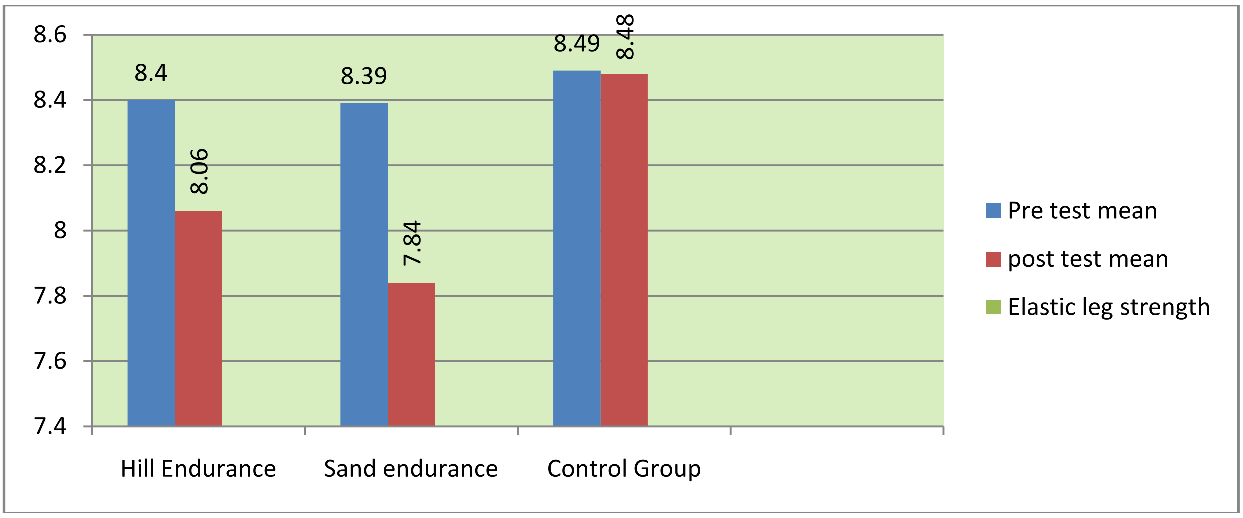
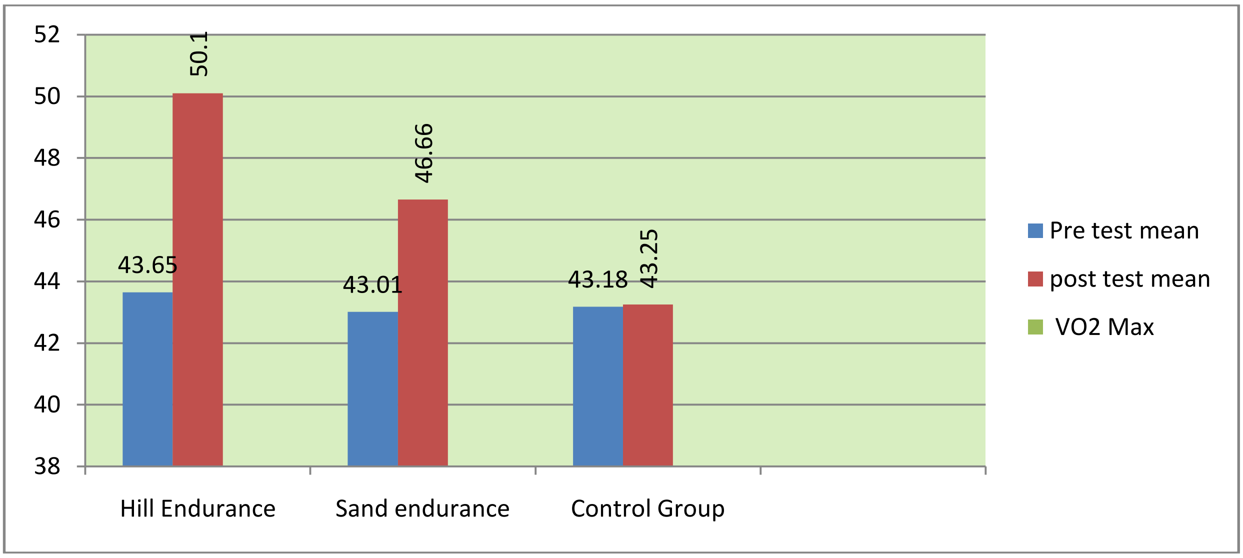


Figure II. The pictorial representation of pre training and post training mean improvement of experimental and control groups on VO_2 Max ml/kg/min.



The significant difference Where shown Between HSG,SSG and CG (Table 3) the obtained F-ratio of elastic leg strength and VO_2 Max for adjusted post test means were 26.13*and 91.34*respectively which are more than the table value of 3.29 for df 2 and 32 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 HSG, SSG for football players would support for the development of the above mentioned experimental variables. The paired mean differences on Elastic leg strength and VO_2 Max of HSG and SSG, HSG and CG, and SSG and CG are Elastic leg strength – 0.22, 0.36 and 0.58 and VO_2 Max – 2.88, 6.44, and 3.56 respectively. These values are greater than the confidence interval values of for Elastic leg strength 0.21, and VO_2 Max – 1.21.The result of the study shows that there were significant differences between HSG and SSG, HSG and CG and SSG and CG since the mean differences were greater than the confidence interval values. While considering the two experimental groups, from the results presented in the table –IV it was found that the HSG was better than SSG on VO_2 Max and SSG was better than HSG on elastic leg strength of high school football players.

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

Criterion Variables	Group	test	Mean	SD	t'- Ratio
Elastic leg strength	HSG	Pre test	8.40	0.2552	3.94*
		Post test	8.06	0.1513	
	SSG	Pre test	8.39	0.2664	5.56*
		Post test	7.84	0.3182	
	Control	Pre test	8.49	0.2703	1.61
		Post test	8.48	0.2596	
VO_2 Max	HSG	Pre test	43.65	1.0757	14.1*
		Post test	50.10	2.0174	
	SSG	Pre test	43.01	1.046	10.69*
		Post test	46.66	1.0688	
	Control	Pre test	43.18	1.2828	1.39
		Post test	43.25	1.2549	

Significant at 0.05 levels. Degrees of freedom n-1=11 is 2.20.

Table III. Analysis of Covariance on Criterion Variables of Experimental Groups (ANCOVA)

Criterion Variables	Adjusted post test means			Source of variance	Sum of Squares	df	Mean Squares	'F'- Ratio
	HSG	SSG	Control					
Elastic Leg Strength	8.08	7.86	8.44	B	1.93	2	0.96	26.13*
				W	1.18	32	0.04	
VO_2 Max	49.78	46.90	43.34	B	243.39	2	121.69	91.34*
				W	42.63	32	1.33	

*Significant at 0.05 level of confidence.
(The table value required for significance at 0.05 levels with df 2 and 32 is 3.29).

Table IV. Scheffe's Paired Mean Difference of Experimental and Control Groups

Criterion Variables	HSG	SSG	Control group	Paired Mean Difference	C.I.Value
Elastic Leg Strength	8.08	7.86		0.22	0.21
	8.08		8.44	0.36	0.21
		7.86	8.44	0.58	0.21
VO_2 Max	49.78	46.90		2.88	1.21
	49.78		43.34	6.44	1.21
		46.90	43.34	3.56	1.21

*Significant at .05 level of confidence.

Discussion

The result of the study shows that 12 weeks of endurance training on hill and sand surfaces for the football players led to increase in elastic leg strength and VO_2 Max. Previous studies have shown improvement on VO_2 Max due to the effect of endurance workout. Such as Nelson et al. (35) found that VO_2 Max was increased in both endurance trained And concurrent endurance- and strength-trained groups, but the increase in VO_2 Max of the concurrent group levelled off after 11 weeks of the 20-week study, whereas the endurance- only group continued to increase Vo2max. A recent study by Paavolainen et al. in 2000 (29) set out to answer this questions.1 the subjects in the study were recruited from three groups: tri athletes, cross country skiers, and middle distance runners. There was no difference between the three groups in their maximum oxygen intake (VO_2 Max) during treadmill running, meaning they were all in roughly the same aerobic shape. However, since the middle distance runners focused on running (and moreover, focused on fast running) in their training, they had what the researchers called better "muscle power factors" than the tri athletes and cross country skiers. So on the preliminary treadmill tests, the middle distance runners had better anaerobic endurance, better top-speed as measured during a 30m sprint, and achieved higher concentrations of lactate in their blood during fast running. Each of these three groups was subjected to a treadmill test measuring their efficiency and performance on two progressively faster treadmill tests—one flat and one with the treadmill set at a 7° incline (a 12% grade, a fairly substantial hill).Surprisingly, the researchers found that aerobic fitness (as measured by VO_2 Max) was a better predictor of uphill running than the "muscle power factors" for all groups. So, while the middle distance runners tended to outclass the skiers and tri athletes on the flat treadmill test, the groups were more or less equal on the uphill running test. The upside of this is that, when training for a hilly race, whether it's a 5k cross country race or the Boston Marathon, you should not lose focus on doing some faster running at close to VO_2 Max pace (between two-mile and 5k race pace), lest you hurt your uphill running performance. Fortunately, doing uphill repeats is itself a great way to train your VO_2 Max. But Boston is infamous not so much for its uphill's, but for its pounding downhill's. Yigit et al 1998 (36) found that VO_2 Max increased significantly for sand runners (1.19 ±0.85%), but not for road runners (0.64 ± 1.35%) or controls (0.13 ± 0.03%) at the end of the 6 – week endurance training program. These findings indicate that endurance running on hill and sand related with aerobic fitness VO_2 max strongly recommend for players at various levels, where as there is lack of findings compare on strength of hill and sand endurance training program. The present study compared that endurance running on both surfaces of hill and sand for the football players at pre season time on aerobic fitness VO_2 max and elastic leg strength was shows significant improvement. Therefore we can state that the increases obtained in leg strength and VO_2 max as a result of 12 weeks training might have been due to these characteristics of hill and sand running endurance training.

Conclusion

The 12-week endurance training program of football players at preseason among two different natural surfaces (hill surface and sand surfaces) led to significant improvement in leg strength and VO_2 max. While considering the two experimental groups, from the results it was found that the Hill Surface Group was better than Sand Surface Group on VO_2 Max and Sand Surface Group was better than Hill Surface Group on elastic leg strength of high school football players.

Practical Applications

Endurance training is a popular and effective method of improving VO_2 Max. In addition, this study suggests that endurance training on different surfaces hill and sand would support for the development of leg elastic strength and VO_2 Max. The results demonstrate that hill surfaces and sand surfaces can be used in sports to improve the aerobic endurance and leg strength such as football, hockey, rugby and other endurance sports.

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