Original Article

Aerobic and Anaerobic Conditioning of Military Personnel and Correlation to Parameters of Body Composition vis-a-vis Endurance and Resistance Trained Athletes

Goswami P*

Abstract

Background: The aim of this study was to investigate the level of fitness and relationship between physical fitness components indicated by aerobic and anaerobic peak power and certain specific body composition parameters in military personnel in non-combat environment. The study compares the above findings in the select group with those of elite endurance trained and resistance trained athletes.

Materials and Methods: 67 resistance trained athletes (Group 1), 70 endurance trained athletes (Group 2) and 70 military personnel (non-athletes, Group 3) were enrolled. Phase I of study involved height and weight measurements, body composition analysis and test of maximal aerobic power (Astrand protocol) using Monark 839 Ergomedic Aerobic cycle ergometer. Phase II involved evaluation of anaerobic power using Monark 894 Ergomedic Anaerobic Cycle Ergometer (Wingate protocol). Body composition analysis was done by impedance method. Correlations were calculated using linear regression analysis. ANOVA was applied to compare the groups.

Results: Parameters like BMI, fat%, fat free body mass and the ratio of fat free body mass to fat mass can be considered in establishing, enhancing and maintaining resilience of mission-fit service member, especially the cardiopulmonary fitness in military and athletic training.

Conclusion: Planned training schedules can assess the progress, monitor the changes and help enhance performance, in individuals who differ in body structure and composition.

Keywords: Aerobic, Anaerobic Fitness, Body Fat, Endurance Trained Athletes, Resistance Trained Athletes

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Introduction

The aim of this study was to investigate the level of fitness and relationship between physical fitness components indicated by aerobic and anaerobic peak power and certain specific body composition parameters in military personnel in non-combat environment. The study compares the above findings in the select group in the military population, with those of elite endurance trained and resistance trained athletes.

It is considered important to assess the effect and result of physical training (endurance training and resistance training) on aerobic and anaerobic fitness in individuals and correlate it with their body composition analysis, so that a relationship can be established between body composition and the modalities of an exercise and physical fitness achieved thereof, in healthy male individuals.

Changing lifestyles and rising expectations are challenges that an Indian soldier is fighting in non-combat environment [1]. Military physical fitness is the ability to physically accomplish all aspects of the mission while remaining healthy and uninjured [2]. As an independent aspect, body composition and physiological performance of trained athletes have aroused the interest of exercise scientists, but studies that combine these aspects in athletes are scarcely available [3].

Material and Methods

The study was a cross sectional research design. The hypothesis was that there is a relationship which can be established between the modalities of exercise done over time and physical fitness

* *Professor, Dept of Physiology, IAM, IAF*

attained thereof and the body composition analysis, performed at the same time, in healthy Indian male individuals. Degree of correlation between parameters of fitness and parameters of body composition depends on the type of physical training received by the individual.

The most effective evaluation of sport-specific performance occurs when the laboratory measurement most closely simulates the actual sport activity and/or uses the muscle mass and movement patterns required by the sport [4, 5]. The following equipments were used in the study:

(a) Cardiopulmonary Exercise Test Assembly

(b) Monark 839 Ergomedic Aerobic cycle ergometer: Measurement of peak VO_2 (L/min and ml/kg/min)

(c) Monark 894 Ergomedic Anaerobic cycle ergometer: Measurement of peak power (Watt and Watt/kg)

(d) Body Composition Analyser: 'In Body 720, Biospace Co. Ltd: By Bio-impedance analysis method

(e) Seca (Vogel and Halke – Hamberg, Germany) balance and stadiometer was used for measuring body weight and height of the individuals.

Healthy male volunteers in the age group 18-40 yrs, who were engaged in body building, weight lifting or other resistance exercises were selected as resistance trained subjects (group A: 67). Individuals, who were engaged in long distance and marathon running, were selected as endurance trained subjects (group B: 70). Control group (group C: 70) comprised of military personnel in the same age group who were non-athletes and working in nearby service units in the medical branch.

A written informed consent was taken from all participants prior to study. Participation of subjects in the study was voluntary and subjects were free to opt out of the study at any time.

Inclusion criteria

(a) Healthy males in the age group of 19 to 42 years

(b) Resistance trained athletes (totaling 67)

(c) Endurance trained athletes (totaling 70)

(d) Military medical personnel who were non-athletes (totaling 70)

Exclusion criteria

(a) Age > 42 years

(b) History suggestive of any medical problem

(c) Patients on medications

(d) Individuals denying consent for the study

The study was conducted in two phases. Phase I (0900h) involved height and weight measurements, body composition analysis and test of maximal aerobic power using Monark 839 Ergomedic Aerobic cycle ergometer, before mid-day [6,7]. Body composition analysis measures fat%, water%, fat free mass%, fat mass, fat free mass, ratio of fat-free mass to fat mass and also, waist-hip ratio [8]. Aerobic power (peak VO_2) was measured through Astrand protocol of incremental load exercise intensity using cardiopulmonary exercise test (CPET) assembly under laboratory conditions [9]. The Phase II (0900h, next day) involved evaluation of anaerobic power using Monark 894 Ergomedic Anaerobic Cycle Ergometer by following Wingate protocol. Adequate rest period was provided between the two tests, which were both conducted in the morning hours.

Astrand Test Protocol A well-established protocol was followed, where the speed was kept constant and the grade of exercise was increased gradually [10]. The protocol involved starting the cycling exercise test at 3.5 mph at a 2.5% grade with a 5 minute warm-up, followed by a continuous multistage run to exhaustion. After 3 minutes at 0% grade, the grade was increased by

2.5% every 2 minutes. This test was suited to testing athletes and fit non-athlete military personnel who belonged to the control group [11].

Wingate Test Protocol The duration of the test in this study was 5 seconds. Resistance to pedaling was applied within 3 seconds after overcoming the initial inertia and unloaded frictional resistance of the ergometer. Though this test can be done for 30 seconds by trained athletes, it does not really matter, how short or long the test is. Anything from 5 seconds up to 200 or 300 seconds is a correct method. In this study, this test was done for 5 seconds by all subjects. The brake weight was calculated as 7.5% of body weight. Flywheel resistance equals 0.075 kg per kg body weight. For a 70 kg person, flywheel resistance would equal 5.25 kg (70kg* 0.075).

After a short warm up, the subject started a quick acceleration. The goal was to reach the maximal pedaling speed. The acceleration was done without any load. The test timer was not started during the acceleration phase. When the subject reached the maximal pedaling speed, the observer (in this study) quickly loaded the flywheel with the brake weight. The test timer was started simultaneously. The subject continued pedaling at maximum speed until the end of the test.

Precision body composition analyzer In Body 720 emits multitude of frequencies including 1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz and 1 MHz using the multi-frequency technology. The frequency of 5 kHz, 50 kHz and 250 kHz were used to measure the resistance and reactance components of body impedance using 8-point tactile electrodes method that was easy to implement and maintained consistency regardless of variations in the test environment.

The following variables were selected to identify significant changes within the groups: body mass (kg), body mass index (BMI), fat mass (kg) (FM), fat free mass (kg) (FFM), body fat percentage (%), fat free mass/fat mass (FFM/FM), waist hip ratio (WHR), peak VO_2 (L/min and ml/kg/min), peak power (Watt and Watt/kg).

Statistical Analysis Correlations were calculated using linear regression analysis. Significance was set at a P-value of lower than 0.05. Test of homogeneity of variance was applied and where $P<0.05$, ANOVA was applied to compare the three groups. Subjects with incomplete data were excluded from the study and statistical analysis of study parameters, which was performed using SPSS Statistics 10.0.

Results

The anaerobic power in Group 1 and 2 (both elite trained athletes, resistance and endurance trained, respectively), is moderately, positively and significantly correlated to BMI, fat free mass, fat %, fat mass and negatively to the ratio of fat free mass to fat mass. Anaerobic power of gp 1 and 3, is significantly positively correlated to weight also.

The mean WHR, fat%, fat mass and weight of gp 3 were the highest. While the aerobic power of the ET athletes, gp 2 was highest and control group or non-athletes, the least. Anaerobic power of the resistance trained group or gp 1 was the highest and ET athletes, gp 2 the least.

The study reveals that improved or an increase in anaerobic power in military personnel, correlates with:

(a) Improved or an increase in FFM:FM ratio

(b) Reduced or a decrease in, the fat mass, fat%, WHR, BMI.

The aerobic power in Group 1 and 2, is moderately and positively correlated to fat free mass%, fat free mass and FFM/FM ratio. There was negative correlation of aerobic power to body fat% and BMI, in all groups; negative correlation of aerobic power to fat mass in gp 2 and gp 3 and to fat free mass in gp 1 & 2 (elite trained athletes). There was a significant correlation (negative) of WHR with aerobic power only in the military non-athlete group.

The study reveals that, during training and physical conditioning, monitoring the following parameters is essential to test progress and trainability in the sport/ physical activity. For improvement in aerobic fitness: -

(a) A reduction in the fat mass, body fat%, BMI.

(b) A reduction in weight and WHR (though here, no correlation was found in endurance trained or resistance trained athletes).

(c) An increase in the FFM/FM ratio.

It is revealed in this study that, in the military, certain useful tested parameters can be considered to monitor progress in training for:

(a) Aerobic fitness, in athletes and controls: Ratio of fat free mass with fat mass, the fat content (fat%, fat mass), BMI, also to an extent, WHR and weight,

(b) Anaerobic fitness, in athletes: Ratio of fat free mass with fat mass, the fat content (fat%, fat mass), fat free mass and BMI, rather than just weight in establishing, enhancing, monitoring and maintaining the fitness and resilience of a mission-fit service member, especially cardiopulmonary fitness in endurance running performance for both military and athletic training.

Table 1. Comparison of physical parameters of resistance trained athletes, endurance trained athletes and military personnel/ non-athletes

Physical parameters	Resistance trained athletes: gp 1		Endurance trained athletes: gp 2		Military personnel (Non-athletes/ controls): gp 3	
	Mean	SD	Mean	SD	Mean	SD
Age	24.36	3.89	25.54	4.48	28.60	7.80
Height	169.73	11.25	172.5	10.59	171.22	5.21
Weight	68.82	14.68	63.11	11.32	69.05	7.93
BMI	23.69	3.45	21.04	2.06	23.56	2.53

Table 2. Comparison of parameters of body composition analysis of resistance trained athletes, endurance trained athletes and military personnel/ non-athletes

Body Composition Analysis parameters	Resistance trained athletes-gp 1		Endurance trained athletes- gp 2		Male military personnel (Non-athletes/ controls)-gp 3	
	Mean	SD	Mean	SD	Mean	SD
Body fat%	14.41	4.58	11.40	3.02	17.87	4.28
FFM%	85.47	4.61	88.56	3.09	82.21	4.34
Water%	59.85	6.18	62.38	3.56	50.36	1.53
WHR	0.85	0.55	0.82	0.04	0.87	0.05
Fat mass	10.35	5.01	7.2	2.39	12.52	4.3
FFM	58.47	10.97	55.9	10.17	56.52	4.79
FFM/FM	6.60	2.54	8.4	2.62	4.94	1.36

Table 3. Comparison of aerobic and anaerobic power of resistance trained athletes, endurance trained athletes and military personnel/ non-athletes

Physical Fitness parameters		Resistance trained athletes (gp 1)		Endurance trained athletes (gp 2)		Male military personnel (Non athletes / controls) - gp 3	
		Mean	SD	Mean	SD	Mean	SD
Aerobic power	L/min	3.05	0.64	3.46	0.78	2.85	3.08
	ml/kg/min	45.18	8.44	55.23	10.6	36.71	8.26
Anaerobic power	Watt	907.57	259.04	677.52	186.63	755.43	225.85
	Watt/kg	13.12	2.45	10.82	2.11	11.11	3.79

Table 4. Correlation of Aerobic Power with Parameters of Body Composition

	RT Athletes: gp 1: Aerobic power		ET Athletes: gp 2: Aerobic power		Military Non-athletes: gp 3: Aerobic power	
	L/min	ml/kg/min	L/min	ml/kg/min	L/min	ml/kg/min
Body Fat%	+0.117 NS (0.336)	-0.442 S (0.000)	-0.277 S (0.023)	-0.318 S (0.009)	-0.194 NS (0.111)	-0.582 S (0.000)
FFM %	-0.111 NS (0.362)	+0.432 S (0.000)	+0.298 S (0.014)	+0.321 S (0.008)	0.192 NS (0.111)	+0.586 S (0.000)
BMI	+0.278 S (0.02)	-0.549 S (0.000)	0.235 NS (0.055)	-0.419 S (0.000)	-0.114 NS (0.346)	-0.504 S (0.000)
Wt	+0.56 S (0.000)	-0.455 S (0.000)	+0.576 S (0.000)	-0.206 NS (0.094)	-0.068 NS (0.578)	-0.403 S (0.001)
WHR	+0.058 NS (0.632)	0.105 NS (0.385)	-0.192 NS (0.120)	0.008 NS (0.951)	-0.107 NS (0.380)	-0.437 S (0.000)
FFM	+0.604 S (0.000)	-0.381 S (0.001)	0.614 S (0.000)	0.144 NS (0.244)	0.027 NS (0.825)	-0.172 NS (0.155)
FM	+0.317 S (0.007)	-0.499 S (0.000)	0.350 S (0.023)	-0.363 S (0.003)	0.155 NS (0.201)	-0.552 S (0.000)
FFM/FM	-0.042 NS (0.732)	+0.436 S (0.000)	0.211 NS (0.180)	+0.260 S (0.033)	0.233 NS (0.052)	+0.602 S (0.003)

Table 5. Correlation of Anaerobic Power with Parameters of Body Composition

	RT Athletes: gp 1: Anaerobic power		ET Athletes: gp 2: Anaerobic power		Military non-athletes: gp 3: Anaerobic power	
	Watt	Watt/kg	Watt	Watt/kg	Watt	Watt/kg
Body Fat%	0.462 S (0.000)	0.115 NS (0.344)	0.238 NS (0.053)	-0.357 S (0.003)	-0.231 NS (0.054)	-0.445 S (0.000)
FFM%	-0.450 S (0.000)	0.113 NS (0.353)	0.210 NS (0.088)	-0.351 S (0.004)	0.229 NS (0.057)	+0.439 S (0.000)
BMI	0.786 S (0.000)	0.348 S (0.003)	0.716 S (0.000)	0.323 S (0.008)	-0.106 NS (0.380)	-0.357 S (0.002)
Wt	0.772 S (0.000)	0.127 NS (0.127)	+0.675 S (0.000)	0.055 NS (0.296)	-0.099 NS (0.416)	0.394 S (0.001)
WHR	-0.127 NS (0.293)	-0.222 NS (0.065)	-0.275 S (0.024)	-0.108 NS (0.384)	-0.150 NS (0.214)	-0.316 S (0.008)
Fat free mass	0.739 S (0.000)	0.120 NS (0.323)	0.620 S (0.000)	-0.007 NS (0.956)	0.008 NS (0.945)	-0.255 S (0.033)
Fat mass	0.644 S (0.000)	0.109 NS (0.368)	0.556 S (0.000)	0.290 S (0.017)	-0.192 S (0.112)	-0.442 S (0.000)
FFM/FM	-0.416 S (0.000)	-0.141 NS (0.244)	-0.259 S (0.034)	-0.399 S (0.001)	0.226 NS (0.060)	+0.441 S (0.001)

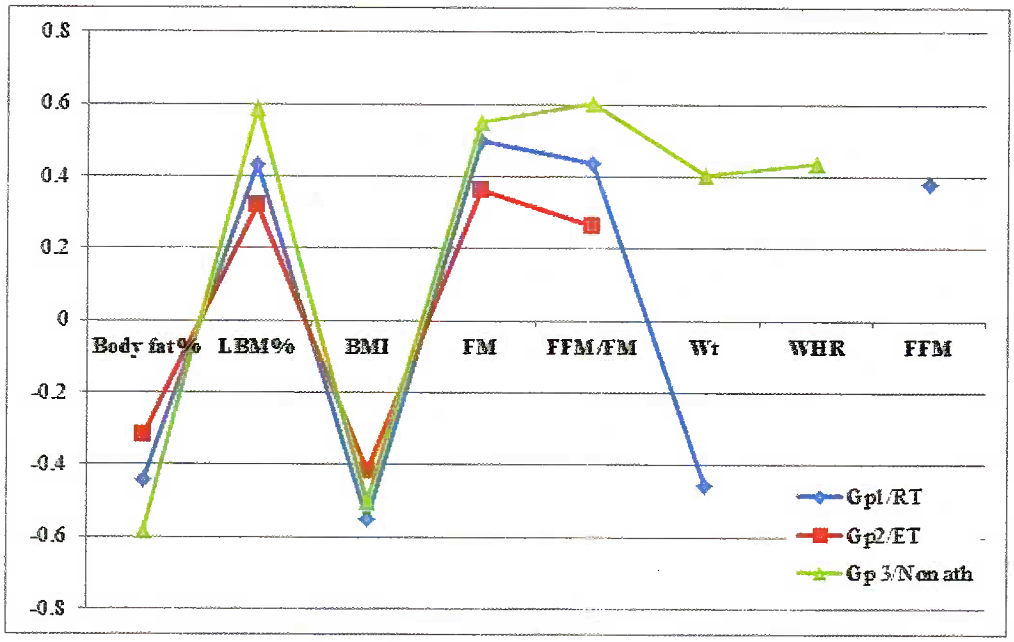

Figure 1: Comparison of correlations of the Aerobic Power (Peak VO_2 in ml/kg/min) with various parameters of Body Composition Analysis, in the three groups. Y axis: +/- correlation values when $P< 0.05$. X axis: parameters of body composition analysis

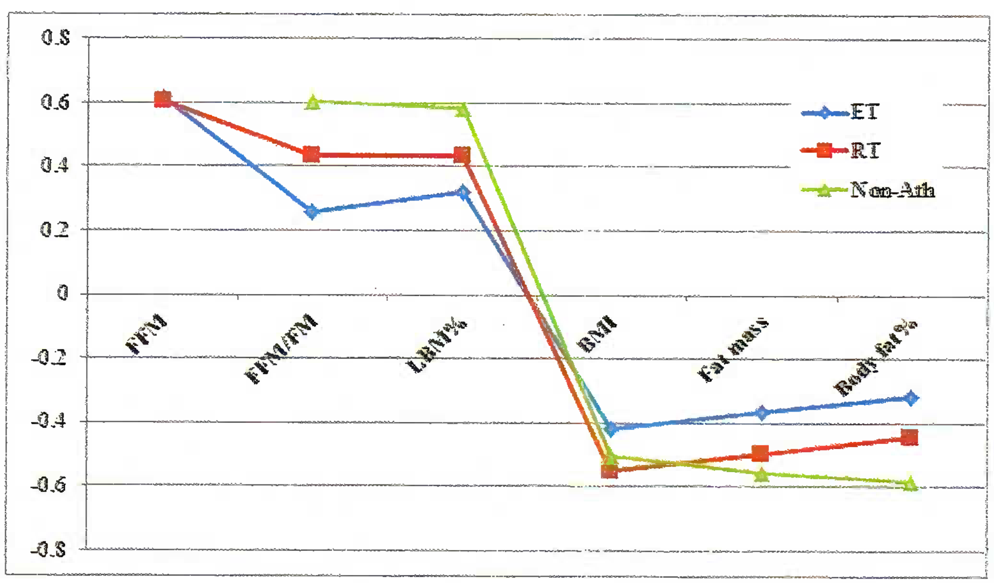

Figure 2: Comparison of correlations of the Aerobic Power (Peak VO_2 in ml/kg/min) with various parameters of Body Composition Analysis, in the three groups.

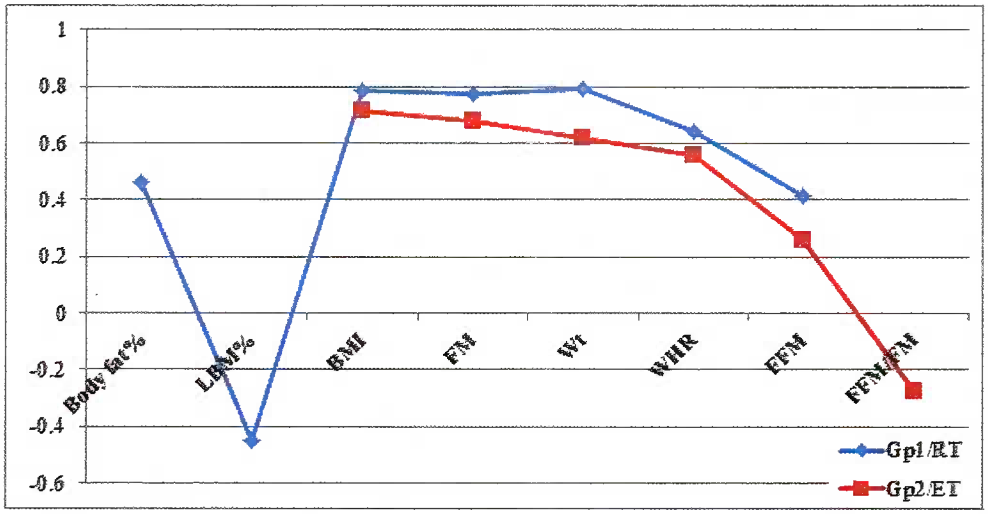

Figure 3: Comparison of correlations of Anaerobic Power (Peak Power in Watt) with various parameters of Body Composition Analysis in the three groups

Discussion

The hypothesis was that specific exercise elicits adaptations to create specific training effects in the Indian healthy male population. This hypothesis means that there is a relationship which can be established between the modalities of exercise and physical fitness attained by endurance and resistance trained elite athletes and their body composition analysis, performed at the same time. The hypothesis stands validated. Physical conditioning of the human body, due to type and intensity of exercise follow alteration-sof body composition that support the activity in athletes [12].

Aerobic conditioning supplies the energy for low intensity exercise over a long duration. Good aerobic conditioning allows a military personnel to recover more completely between shifts. Aerobic capacity is basically how long a person can go without running out of breath and how quickly he can recover from physical exertion.

Anaerobic conditioning of the body is important for the short bursts of energy. Anaerobic conditioning enhances stamina which allows an individual to continue the task at hand for a longer period of time before the accumulation of lactic acid in the body exceeds its ability to remove it. In addition, the body becomes more efficient and produces less lactic acid and fosters lactic acid toleration.

Correlation between the parameters of fitness (aerobic/anaerobic power) and certain parameters of body composition exists and to different degrees in each group of individuals; analysis of correlations can be used to understand, guide and monitor the progress in training. Correlation, in athletes, depends on the group's response to regular training, as seen in this study on two types of athletes, resistance trained (gp 1) and endurance trained (gp 2) and the response by changes that occur in body composition in an individual to either endurance training or resistance training.

Recognition of the degree of correlation of parameters of fitness and the type of training received, and body composition arrived at, can be projected in monitoring of training schedules, and demonstrating presence or absence of improvement. Planned schedule of physical activity that includes a regular check of trainability of individuals can monitor the progress of 'the right stuff' at periodic intervals. When supervisors/ trainers are armed with the knowledge of correlations of parameters, this helps monitor and guide the training in individuals who differ in body structure and composition. Physical fitness and superior performance is a product of complex interaction of physiological, genetic and nutritional factors [13, 14, 15].

Principle of individuality means that individuals are unlikely to show precisely the same responses [16]. There are high responders and there are low responders [17]. Any training programme must take into account the specific needs and abilities of the individuals for whom it is designed [18].

Principle of specificity means that athletes who train for strength and power, such as weightlifters often have great strength but do not have highly developed aerobic endurance when compared to the non-athletes (here, military personnel) [19]. Exercise adaptations are specific to the mode and intensity of training [20]. Training programmes stress the physiological systems critical for optimal performance, achieving specific training adaptations.

In the military personnel, training that brings improvement of muscle mass and decrease of fat content will increase aerobic fitness, and that which improves only the former, i.e, muscle mass, will improve anaerobic fitness. Therefore the degree of improvement can be monitored at regular intervals, using the parameters suggested, to guide physical conditioning / training and to optimize performance in either aerobic or anaerobic physical activity.

Conclusion

By following individual-based supervised physical training and reducing the fat mass, fat %, WHR, non-athletes in military would, attain an improvement in both aerobic power, with guidance on progress. By regularly observing and increasing an individual's fat free mass% and FFM/FM ratio while attaining the physical conditioning that fitness training entails, both aerobic and anaerobic power can be improved, in a goal-oriented manner.

The study reveals that the best correlate of aerobic power is FFM/FM, then body fat mass, followed by body fat%. The study also reveals that BMI has significant negative correlation with improvements in aerobic power and WHR has no correlate in athletic group with either aerobic/ anaerobic power.

A training program requiring a higher oxygen delivery, leads to greater adaptations of the oxygen delivery system. Continuous endurance training and high intensity training lead to significant improvements of aerobic capacity and body composition. High intensity training is favourable to improve VO2 peak. Burning body fat requires a rigorous cardiovascular regimen and exercise program. When strength training is also incorporated, muscle tone improves and more calories are burnt at rest.

If the goal is to reduce body fat and increase endurance, a balanced program of Aerobic and Resistance Exercise will help reach the goal, with regular and adequate monitoring.
Throughout the duration of a training programme, one needs to know if the weight gained or lost, is lean muscle or fat, and how balanced the development is. This is why, obtaining a detailed analysis of body composition is so important before, during and after the training. Both in military and athletic training, it is important to plan the individual's exercise schedule according to his need, then track the progress of training, while utilizing technology to obtain information on body composition analysis to develop and monitor the training programmes.

References

1. VM Malhotra, A Upadhyaya, BS Suhag, H Khanna; Total Force Fitness: A comprehensive Health Model for Indian Army in the 21st century, JCMSL Vol 2, No. 2, 2012-13, 60-65.

2. Total Force Fitness: A new paradigm. Samueli Institute Health Policy document. Available at www.samelineinstitute.org/health policy/total-force-fitness.

3. M.L. Pollock, G.A. Gaesser, J.D. Butcher, J.P. Despres, R.K. Dishman, B.A. Franklin, C.E. Garber. The Recommended Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in

Healthy Adults. Medicine & Science in Sports & Exercise Vol. 30 #6.

4. Clarke DH, Clarke HH. Research processes in physical education, recreation and health.Engelwood Cliffs, NJ: Prentice-Hall,1984.

5. Fletcher GF, et al. Statement on Exercise: Benefits and recommendations for physical activity programmes: American Heart association. Circulation 1996; 94: 857.

6. Wenger, H. A., & Bell. G.J.(1986). The interactions of intensity, frequency, and duration of exercise training in altering cardiorespiratory fitness. Sports Med., 3, 346-356.

7. Howley ET, Bassett DR Jr, Welch HG: Criteria for maximal oxygen uptake: review and commentary. Med Sci Sports Exerc 27: 1292-1301, 1995.

8. Satyanarayana K, Naidu AN, Chatterjee B, Rao SM: Body size and work output. Am J ClinNutr 30: 322-325, 1977.

9. Johnson MS, Figueroa-Colon R, Herd SL, et al: Aerobic fitness, not energy expenditure, influences subsequent increase in adiposity. Paediatrics 106: E50, 2000.

10. Lee CD, Blair SN, Jackson AS: Cardiorespiratory fitness, body composition and cardiovascular disease mortality in men, Am J ClinNutr 69: 373-380, 1999.

11. Chris Slentz, BrunildaNazario, Miranda Hill: Exercise fights hidden body fat, Journal of Physiology , Sep 2005 (Web MD Health News).

12. American College of Sports Medicine. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory & muscular fitness in healthy adults. Med Sci. Sports Exerc. 1990; 22:265-274.

13. Hottenrott K., Ludiga S., Schulze S.: Effects of High Intensity Training and Continuous endurance training on Aerobic capacity and body composition in recreationally active runners. Journal of Sports Science and Med (2012) 11, 483-488.

14. Physiological Research ISSN 0862-8408. Effects of Body Mass Index on Maximal Work Production Capacity and Aerobic Fitness during Incremental Exercise. Physiol. Res. 53: 165-170, 2004.

15. Bouchard C., Shepard RJ: Physical activity, fitness and health: the model and key concepts. Human Kinetic. 1994, pp 77-88.

16. Hansen JE, Sue DY, Wasserman K: Predicted values for clinical exercise testing. Am Rev Respir Dis., 129: 49-55, 1984.

17. Hollman W: Historical remarks on the development of the anaerobic threshold upto 1966. Int J Sports Med 6: 109-116, 1985.

18. Kohl HW, Blair SN, Paffenbarger RS, Jr., Macera CA, Kronenfeld JJ. A mail survey of physical activity habits as related to measured physical fitness. Am J Epidemiol. 1988;127(6):1228–39. [PubMed]

19. Wasserman K, Hansen JE, Sue DY, Whipp BJ: Principles of exercise testing and interpretation. Lea and Febiger, Philadelphia, 1994, p: 18-72.

20. Rump P, Verstappen F, Gerver WJ, Hornstra G: Body composition and cardiorespiratory fitness indicators. Int J Sports Med 23: 50-54, 2002.

21. Ozcelik O, Dogan H, Kelestimur H. Effects of eight weeks of exercise training on body composition and maximal exercise capacity in obese females. Public Health. 2006 Jan; 120(1):76-82. Epub 2005 Sep 29.

22. Ozcelik O, Ozkan Y, Algul S, Colak R. Beneficial effects of training at the anaerobic threshold in addition to pharmacotherapy on weight loss, body composition, and exercise performance in women with obesity. 2015 Jul 13;9:999-1004. Patient Prefer Adherence; doi: 10.2147/PPA. eCollection 2015.

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