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**EFFECT OF CHANGES IN BODY COMPOSITION PROFILE ON VO<sub>2</sub> max AND  
MAXIMAL WORK PERFORMANCE IN ATHLETES**

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**ABSTRACT**

EFFECT OF CHANGES IN BODY COMPOSITION PROFILE ON VO<sub>2</sub>max AND MAXIMAL WORK PERFORMANCE IN ATHLETES. **Venkata Ramana Y, Surya Kumari MVL, Sudhakar Rao S and Balakrishna N. JEPonline. 2004;7(1):34-39.** This study describes the changes in body composition profile and in turn the relationship to maximal work performance across three phases of athlete training. Ten national level male distance runners aged between 18 and 22 years from Sports Authority of Andhra Pradesh were studied during their transition (TP), Pre-competition (PP) and Competition (CP) phases of training. Body height, weight and circumferences were measured. Body composition was assessed by using skin-fold thickness at four sites. Physiological parameters such as VO<sub>2</sub>max (by means of indirect calorimetry) and maximal work performance (WRmax) were estimated from treadmill running using the Bruce protocol. Quantification of training was done by the Time Allocation Pattern (TAP) and heart rate-work rate relationships. The results indicated a significant (P<0.001) increase in Lean Body mass (LBM) by 4.7%, VO<sub>2</sub>max (18%) and maximal work performance (WRmax) by 37% from TP to CP. The change in training during this phase transition was 1.6 fold for intensity and 2 fold for duration. In addition, there were high significant correlations between LBM and VO<sub>2</sub>max, and WRmax and VO<sub>2</sub>max. Thus, this study suggests that the body composition is an important component in training-induced adaptations, and may influence various physiological parameters resulting in an enhanced maximal work performance.

Key Words: LBM, Work rate, Training, Performance, Nutritional Status.

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**INTRODUCTION**

Optimal body dimensions are one of the most important pre-requisites of physical fitness and performance (1). Adaptation to exercise is manifested by changes in body weight, body build and body composition and by changes in the absolute and relative aerobic capacity (2). It would be interesting to observe trends in performance changes in different sporting/athletic events especially in those where the intensity and regimen of training program and achieved results were enhanced most profoundly. Body composition data of athletes are very scanty, and it would be useful to define these changes more precisely because their analysis could

contribute in a significant way to the definition of the optimal morphological type and measures leading to desirable changes to improve athletic performance.

Body composition reflects the overall nutritional status of an individual (3), and LBM is one of several important parameters that can influence performance on any given physical task, especially sporting and athletic events. The variation in intensity and duration of training brings about changes in body weight, composition and metabolic and physiological parameters (4). Therefore, the periodic completion of accurate appraisals of body composition in relation to the amount of training given provides an opportunity to assess current status and training adaptability of an athlete. This would help the coaches to manipulate the training program to achieve optimal or desirable body weight, body composition and peak performance levels. Therefore, this study was carried out to identify the variations in body composition profile (LBM & fat mass) with incremental training load and in turn its relationships to  $VO_2$ max and maximal work performance.

## METHODS

Ten healthy national level male distance runners representing Andhra Pradesh State in national events, aged between 18 and 22 years, were recruited from Sports Authority of Andhra Pradesh, Hyderabad, India. They were briefed about the purpose and scope of the study protocol and their written consent was obtained based on the guidelines of the institutional ethical committee. The subjects were brought to the laboratory from the sports hostel soon after waking in the morning and were asked to rest for an hour in a supine position in an awakened state. The Athletes were then subjected to anthropometric measures such as height, weight, circumferences at upper mid-arm, waist and hip. Height was measured to nearest to 0.1 cm using a height rod (SECA, Germany). Body weight with minimum clothing was measured nearest to 0.1 kg on a lever type balance (SECA, Germany) in a fasted state after emptying the bladder. Skin-fold thickness measurements were taken at biceps, triceps, sub-scapular and supra-iliac sites with skin-fold calipers (Holtain, U.K.), having an accuracy of 0.2 mm. Skin-folds were incorporated into the age and sex matched equations of Durnin & Womersley (5) to derive body density. Body fat percentage was calculated using the Siri equation (6), from which the LBM was derived.

Work performance and oxygen consumption at maximal exertion were estimated from the completion of a treadmill graded exercise test using the Bruce protocol (7). Indirect calorimetric method by using Douglas bags was used to measure  $O_2$  consumption at different stages of the Bruce protocol and the end point was considered as  $VO_2$  max (8). The collected expired air samples in the Douglas bags were analyzed for volume (Singer dry gas meter, DTM325, USA), for oxygen (Taylor's Servomex- paramagnetic analyzer-OA272, UK), for  $CO_2$  (LB-2, Beckman's infrared analyzer, USA), after prior calibration. The values were corrected to STPD. Online heart rates were measured using a heart rate monitor (PE-3000, Polar Instruments, Finland). Quantification of training in terms of intensity and duration was done by using the time allocation pattern (TAP) (9), heart rate monitoring (10) and also using oxygen-heart rate and heart rate-work rate relationships (11,13). The same protocol was used during transition phase (TP), pre-competition phase (PP) and competition phases (CP) of training.

### Statistical Analyses

The data was analyzed using standard statistical package (SPSS version 10.1). ANOVA and multiple comparisons were carried out to test the differences that are brought about in physical and physiological parameters between the phases of training. The values were expressed as Mean  $\pm$  SD. Significance was accepted at  $p < 0.05$ .

## RESULTS

The physical characteristics pertaining to anthropometry and body composition profile were presented in Table 1. The mean height was significantly increased by 0.9 cm from TP to CP. A considerable increase of about 2.5

kg in weight was observed in these athletes from TP to CP, out of which about 1.6 kg was increased from TP to PP and the remaining 0.9 kg gain was observed from PP to CP.

**Table 1. Anthropometry and Body Composition of Athletes (n=10)**

Parameters	TP	PP	CP	F-Ratio	P-value

All values are expressed as Mean±SD; variation in superscript indicates significance for the difference between the Mean values of phases. NS=Not Significant.

It was apparent from the results that an increase in LBM altered the body composition of the athletes without much variation in the fat content from TP to CP. The LBM was significantly increased by 4.7% (2.1 kg) from TP to CP, out of which 3% was observed between first two phases of training (TP to PP). However, no significant change was observed in percent fat content from TP to CP.

The results of the physiological profile were shown in Table 2. The VO<sub>2</sub>max was significantly increased by 18.3% with an increase in minute ventilation by 17.6% from TP to CP. It was also observed that there was a 13% increase in maximal oxygen consumption when expressed in terms of either unit body weight or lean body mass. On the other hand, the work rate was also increased significantly by 37%, with an increase in mechanical efficiency by 4% and oxygen pulse by 19% from TP to CP.

**Table 2. Physiological Profile of the Athletes in Different Phases of Training (n=10)**

Parameters	TP	PP	CP	F-Ratio	P-value
<b>VO<sub>2</sub>max</b> (ml/min)					
<b>MV<sub>E</sub></b> (l/min)					
<b>HR</b> (bpm)					
<b>O<sub>2</sub> Pulse</b> (ml/beat)					
<b>Work rate</b> (kpm/min)					
<b>ME</b> (%)					
<b>O<sub>2</sub>-Kg.bwt</b> (ml/kg/min)					
<b>O<sub>2</sub>-LBM</b> (ml/kglbm/min)					

All values are expressed as Mean±SD; variation in superscript indicates significance for the difference between the Mean values of phases., NS=Not Significant.

The LBM and fat % were closely correlated with height, weight and BMI. The VO<sub>2</sub>max was closely correlated with height, weight, LBM and maximal work rate in all the phases of training (Table 3). The oxygen pulse of these athletes was highly correlated with LBM and maximal work rate.

**Table 3. Correlation Co-efficient of Physical and Physiological parameters (n=10)**

Phase	Parameter	Weight	VO <sub>2</sub> Max	Work rate	O <sub>2</sub> Pulse
	VO <sub>2</sub> Max				
	O <sub>2</sub> pulse				
	VO <sub>2</sub> Max				
	O <sub>2</sub> pulse				
	VO <sub>2</sub> Max				
	O <sub>2</sub> pulse				

\*P<0.05, \*\*P<0.01, \*\*\*P<0.001.

The training schedules of athletes were quantified in terms of duration and intensity (kpm/min) along with energy expenditure. The intensity of training was quantified in terms of absolute work rate. These results were presented in Table 4.

**Table 4. Quantification of Training in Different Phases (n=10)**

Phase	Duration (min)	Intensity (kpm/min)	Work rate (kcal/min)	Energy expenditure (kcal)
TP				
PP				
CP				

All values are expressed as Mean±SD; variation in superscript indicates significance of difference between the Mean values of phases.

The mean total training duration was significantly increased 1.9 fold from TP to PP, while it was increased 2.1 fold from TP to CP of training. The mean total work intensity in a day’s training was found to be about 672 kpm/min in TP and was significantly increased by 1.29 fold in PP and 1.63 fold during CP.

**DISCUSSION**

Body composition and weight are two of the many factors that contribute to optimal athletic performance. Taken together, these two factors may affect an athlete’s potential for success within a given sport. Most athletes require a high strength to weight ratio to achieve optimal athletic performance. As body fat adds to weight without adding to strength, less body fat percentages are often emphasized for better performance by many researchers (14-16).

In order to achieve desirable weight, composition and peak performance athletes undergo different phases of training prior to the actual competition by manipulating intensity, duration and type of training (17). Hence, periodic evaluation of body composition changes and in turn physiological profiles provide important guidelines for appropriately developing a progressive program of training.

Regular involvement of athletes in physical training have led to considerable alterations in body composition (18), and have been shown to be closely related to the aerobic capacity and maximal work rate of athletes (19-25). Similar observations were made in the present study in that the athletes received an incremental 2 fold increase of in training duration and 1.6 fold increase in training intensity from TP to CP. Such changes

coincided with an increase in 2.5 kg body weight and 4.7% in LBM, without much variation in the fat content of the body. This in turn coincided with an improvement in aerobic capacity by 18% and maximal work performance by 37% from TP to CP.

## CONCLUSIONS

Based on the observations made in this study, it is evident that with the increase in intensity of training there was a considerable improvement in the functional parameters related to cardiovascular and cardiopulmonary systems leading to improved aerobic capacity. It is tempting to speculate that this was mainly brought about as a consequence to an increased mass of metabolically active tissue (increased LBM) from TP to CP. However, we cannot provide definitive comments on the cause-effect relationships between the body composition and cardiopulmonary changes of the athletes. Nevertheless, it is reasonable to suggest that athletes should be monitored for their body composition periodically to help their trainers in constructing suitable training programs to achieve desirable body weight and composition for more optimal sports performance. Further, it is the opinion of the authors also that monitoring body composition periodically becomes much more crucial and important in weight category sports such as boxing, wrestling, weight lifting, where the body weight becomes the selection criteria and lean to fat ratio would decide the performance outcome.

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