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Heart Rate Responses of Adult Male and Female Runners During 3000 Meter Running

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KEY WORDS Heart Rate, VO_2max, 3000M Running, PWC_{170}.

ABSTRACT The study was conducted on 50 adult male and 50 adult female students of different courses studying at Indira Gandhi Institute of Physical Education and Sports Sciences, New Delhi. The age of the subjects ranged between 18-24 years. Physical work capacity (PWC_{170}) and VO_2max of the subjects were predicted from minute heart rates measured at two submaximal work loads of 50 and 100W intensities on bicycle ergometer. The minute heart rate responses of all the subjects were also measured with the help of a sport tester during all the 15 laps (each lap of 200M) of 3000M running in the track. Results of the study indicate that females on an average demonstrate 10-12 beats/min greater heart rate (HR) response than their male counterparts at the two submaximal workloads on bicycle ergometer. This is indicative of better cardio-respiratory fitness of males than the females of the present study. Regarding HR response of both the sexes to 3000m running, male runners have been found to increase their HR from an average value of 173.42 beats/min. (lap-1) to 202.78 beats/min. recorded during the last i.e the 15th lap as compared to the corresponding values of 185.8 and 206 beats/min recorded in case of female runners. Thus sex differences have been found to exist in the HR responses to 3000M running with males exhibiting lower heart rates than females in comparable laps which suggests better cardio-respiratory endurance in the former than the latter.

INTRODUCTION

Recent decades have witnessed a remarkable expansion of applications of scientific principles to sport and exercise. Developments are such that most international teams now have systematised scientific back up when they prepare for major competitions. This is revealed by the bettering of running performance records year after year since the beginning of 20th century. A large number of studies are available in the literature which suggest an extensive exploration from almost all scientific angles of sprinting (Mero et al., 1981; Doolittle and Tellez, 1984; Cheetham et al., 1986; Moravec et al., 1988;) and marathon running (Costill, 1970; Pollock, 1977; Maughan and Leiper, 1983; Saltin, 1986; Pollock et al., 1987). Events like 3000M running which require a combination of both speed and endurance have not been scientifically pursued with the same vigour as sprinting and marathon running (Leger and Mereier, 1984; Newsholme, 1986; Medbo et al., 1988 and Snell, 1990). In India, the situation is more pathetic as judged from the fact that this area has been left virgin and largely ignored. The present endeavour has therefore been undertaken on young adult male and female runners to study their heart rate responses during 3000m running.

MATERIAL AND METHOD

The study was conducted on 50 adult male and 50 adult female students of different courses studying at Indira Gandhi Institute of Physical Education and Sports Sciences, New Delhi, after obtaining their consent. The age of the subjects ranged between 18-24 years and they were free from any medical contraindications. Minute heart rate responses of the subjects were measured at two workloads of 50W and 100W on a Monark bicycle ergometer at 50 revolutions/min. with the help of a Polar Heart Rate Monitor. The duration of exercise at each workload was kept five minutes. Heart rate (beats/min.) were plotted against the two workloads and thereafter by extrapolation method, work intensity corresponding to heart rate value of 170 beats/min. was calculated. This value served as PWC_{170} and from its expression in relation to the body weight of the subject, VO_2max/kg/min. was calculated by the following formula:

$$VO_2\text{max (ml/kg/min.)} = 1.66X + 22.94$$

where $X = PWC_{170}$ /kg body wt.

The heart rate during the entire course of 3000m running, comprising of 15 Laps each of 200m on the track, was also measured with the help of sport tester. Before the start of a 3000m run, a sport tester was attached at the wrist and a telemagnetic belt of sport tester around the chest of the subjects and was duly checked for the reception of signals. Time taken to complete each lap of 200 meters was recorded by a video camera installed in the field.

RESULTS AND DISCUSSION

The results pertaining to the study have been presented and discussed as follows:

(i) Minute Heart Rate Response to Submaximal workloads on the Bicycle Ergometer and Physical Work Capacity.

(ii) Heart Rate Response during 3000M running.

(iii) Physiological interpretation of 3000M running Performance among the two sexes.

(i) Minute Heart Rate Response to Submaximal workloads on the Bicycle Ergometer and Physical Work Capacity

Table 1 enlists the mean steady state minute heart rate values observed in the male and female runners at the two bicycle ergometric loads. The calculated PWC_{170} and VO_2 max values of the subjects are also enlisted in the table. The results of the study indicate that males on an average attain lower steady state minute heart rate values at 50W and 100W workloads than the females. The heart rate difference between the two sexes at these workloads have been found to be 11 to 12 beats/min. In nutshell, females increase their heart rate more than the males from their resting state to perform these two submaximal efforts on bicycle ergometer which is indicative of better cardio-respiratory fitness in the latter.

The ability to do physical works of long duration that is tasks which are aerobic in nature depend upon the fitness of various systems of the body like cardio-vascular, respiratory and muscular systems etc. The physical work capacity at heart rate of 170 beats/min is considered to be a good measure of ones ability to do prolonged work of steady state nature. Table 1 provides the mean values of both PWC_{170} as well as PWC_{170}/kg body weight observed in male and female runners. Males are found to be superior than their female counterparts in their ability to achieve higher PWC_{170} values, which like the earlier observation noted on these runners on cycle ergometric loads, again is suggestive of better ability of the former in executing prolonged tasks of steady state nature than the latter Expression of PWC_{170} in relation to the respective body weights of the subjects however, reveal comparable values among the two sexes with only a slight advantage in favour of males. Males thus lose much of their superiority over females in their abilities to do tasks of maximal nature when weight factor is accounted for in the subjects. This view derives strength when the values of predicted VO_2max are compared in the two sexes. Male and female runners in the present investigation are found to possess comparable maximum oxygen uptake values as revealed from table 1. The results of the study thus indicate differences among the two sexes in their abilities to do exercise tasks of submaximal nature but reveal comparable physiological abilities in them to undertake maximal exercise.

Comparison of maximum oxygen uptake values of male runners of the present study with the values reported on adult males by Verma et al. (1999) reveal higher values in the former. The reason for this seems to be the active lifestyle of the present group of subjects who are regularly involved in sports activities as a part of their college curriculum.

Table 1: Minute heart rate responses of male and female runners to bicycle ergometric exercise

S. No.	*Variable*	*Males*		*Females*	
		Mean	*S.D.*	*Mean*	*S.D.*
1	Minute Hr (Beats/Min) 50W	132.7	2.0	144.7	2.15
2	Minute Hr (Beats/Min) 100W	147.4	2.3	158.5	2.05
3	PWC_{170} (kpm)	1059.7	70.8	852.1	65.0
4	PWC_{170}/kg body weight	17.2	1.9	16.9	1.9
5	VO_2max/kg/min (ml.)	51.4	3.2	51.0	3.1

(ii) Heart Rate Response to 3000m Running

Table 2 gives the mean values of minute heart rates recorded during each lap of 200m in 3000m running on the track, of male and female runners. It is apparent from the table that minute HR response increases with the progression of 3000m run in both male and female runners. Mean minute HR has been found to increase from 173.4 beats/min. (85.5 % of Hr_{max}) during lap-1 to a maximal value of 202.8 beats/min. during lap-15 in case of males and corresponding increases in females

Table 2: Minute heart rate responses of male and female runners during different laps of 3000m running

Lap No.	*Minute hr males (Beats/min)*			*Minute hr females (Beats/min)*		
	Mean	*S.D.*	*% HRmax*	*Mean*	*S.D.*	*% HRmax*
LAP-1	173.4	19.2	85.5	185.8	5.8	90.2
LAP-2	184.2	16.9	90.9	189.0	5.8	91.8
LAP-3	184.5	31.5	91.0	191.5	5.3	92.3
LAP-4	189.3	16.9	93.3	193.3	5.5	93.8
LAP-5	192.2	8.5	94.8	195.1	5.0	94.7
LAP-6	193.5	8.2	95.4	196.0	5.9	95.1
LAP-7	193.8	8.6	95.6	197.2	6.1	95.7
LAP-8	194.6	8.5	96.0	198.1	6.4	96.2
LAP-9	195.3	8.7	96.3	199.0	6.4	96.6
LAP-10	196.0	8.5	96.7	200.7	6.5	97.4
LAP-11	195.9	8.7	96.6	201.5	6.4	97.8
LAP-12	196.5	8.6	96.9	201.7	6.6	97.9
LAP-13	197.3	8.6	97.3	203.0	6.6	98.5
LAP-14	199.0	8.4	98.2	205.1	6.2	99.5
LAP-15	202.8	7.9	100	206.0	6.5	100.0

are from 185.8 (90.2 % of Hr_{max}) to 206 beats/min respectively. Both the group of runners demonstrate minute HR values which in relation to their maximal heart rates are observed to fall in the range of 90 to 100 % during the entire course of running.

Following observations can be derived from table 2 and figure 1.

(a) Male runners on an average demonstrate lesser HR response than their female counterparts during all the stages of 3000m running. In quantitative terms, the minute HR in male runners of the present study tends to remain 2.5 to 12.4 beats/min lower than the females during corresponding laps of running.

(b) An analysis of the trends in average differences recorded in the magnitude of minute heart rates of the male and female runners during corresponding laps of running the race reveal an interesting picture (Fig. 1).

During the initial stages of running (laps 1 to 3), the magnitude of difference in minute heart rates is observed to be greater among the two sexes, followed by a reduction in this difference (laps 3 to 6) where after the magnitude of difference stabilises as is observed from minute HR values exhibited by male and female runners in laps 7 to 9 (table 2 and figure 1). In the subsequent laps of running the race, the magnitude of difference in the minute HR among the two sex groups once again starts increasing so much so that in the 14th lap, the average difference in HR builds to 6.1 beats/min. In the final lap of 3000m running, maximal minute heart rate values are exhibited by the runners and the magnitude of difference in male and female runners at this stage of running has been found to reduce to 3.2 beats/min.

(iii) Physiological Interpretation of 3000m Running Performance Among the Two Sexes

A comparison of time taken to complete different laps of 3000m running is made in table 3 and fig 2. Following observations are derived from the data presented in the table:

(i) Male runners take less time to complete each lap than their female counter-parts and thus complete the 3000M race in 812.96 seconds as compared to 990.40 seconds recorded in the latter. On an average the male runners in this manner accomplish the race about 177 seconds ahead of female runners.

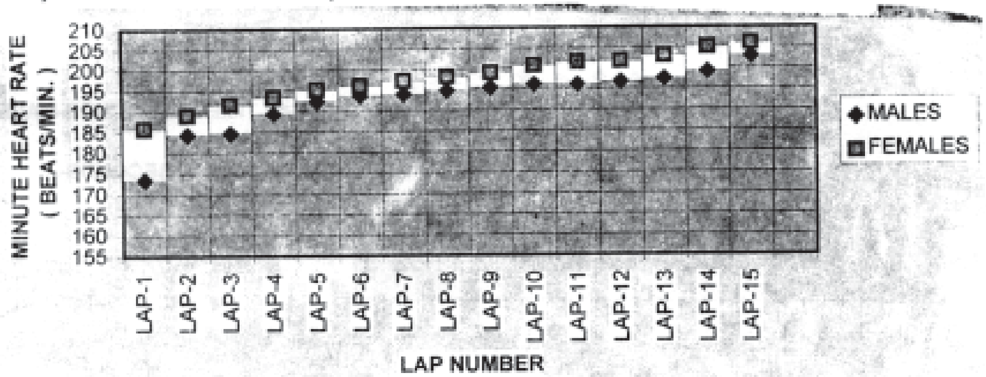

Fig. 1. Lapwise comparison of minute heart rates of male and female runners during 3000m running on the track

(ii) Female runners exhibit a steady state running from lap-1 to lap-12 ,as is evident from the values of various lap timings (range 65.45-66.55 secs) recorded in them during 3000m running . Males on the other hand are observed to show variations in their lap performances.

(iii) Males run the first lap in 47.5 secs as compared to 66.5 secs taken by females whereafter females maintain a steady state running upto 12th lap while their male counterparts tend to slow down upto 7th lap and there-after demonstrate a steady running upto lap 13th. It must be noted that inspite of slowing down noticed in males, their lap timings still remain lower than the female runners .

(iv) During the last two to three laps of running the 3000m race, both males and females exhibit a tendency to accelerate but with varying magnitudes. Male runners increase their speed of running much more during this phase of the race than the female runners.

Physiologically speaking 3000m running require abilities common to that of shorter (i.e. sprinting) events and longer events (i.e. marathon) or in other words it is a combination of both speed and endurance. Ability to consume oxygen maximally in athletes has been reported by many investigators to be highly linked to performance in endurance tasks (Shephard et al., 1973; McArdle et al., 1991; Mero et al., 1991 and Verma et al., 1999). As per these findings, there should not have been any difference in the performance of male and female runners because of comparable VO_2max values possessed by them. But the fact is contrary to this, as large differences in 3000M performance among the two sexes have been noticed in the present study.

Table 3: Comparison of lap timings among male and female runners

Lap number	*Lap time (Secs.) mals*		*Lap time (Secs.) females*	
	Mean	*S.D.*	*Mean*	*S.D.*
1	47.45	7.62	66.50	2.80
2	49.83	6.88	66.55	2.18
3	51.53	5.29	66.30	2.29
4	54.08	6.15	66.28	2.11
5	53.72	5.60	66.20	2.03
6	54.85	5.78	66.16	2.15
7	55.51	6.07	66.14	2.28
8	56.94	7.54	65.96	2.13
9	57.53	7.71	65.77	2.02
10	56.59	6.36	65.65	2.26
11	57.83	10.84	65.72	3.00
12	57.02	6.97	65.45	2.66
13	57.26	8.46	64.70	1.73
14	54.35	7.00	64.11	1.77
15	45.39	7.64	63.85	1.85
Total Time	812.96	77.84	990.40	27.37

This needs to be interpreted in the light of the findings related to the onset of anaerobic threshold (AT) during exercise reported by Wasserman (1985) and explored further by Hofmann (1994). According to them, variability in endurance performances among individuals with similar VO_2max can be ascribed to the differences in the onset of anaerobic metabolisms i.e. anaerobic threshold levels. They further reported that among better endurance performers, onset of AT is delayed during exercise and occurs at very high levels of their % VO_2max. The same reasons are thought to be responsible for

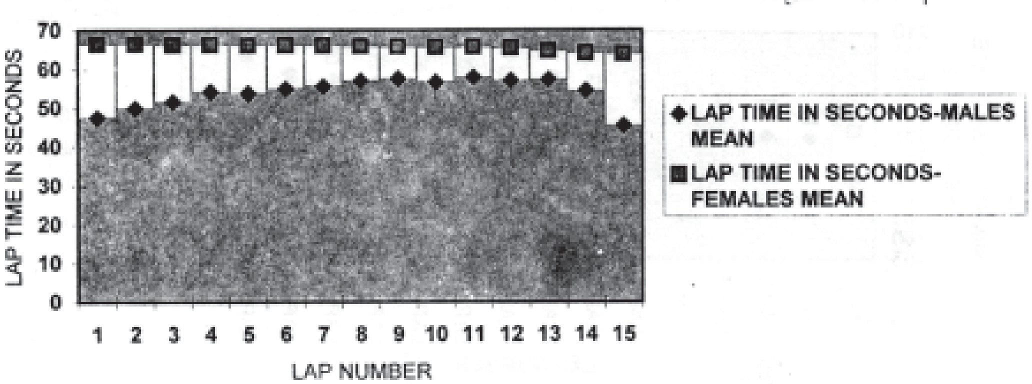

Fig. 2. Comparison of lap timings during 3000m running on the track in male and female runners

the differences in 3000M running performance among the two groups of the present study. Male runners of the present study complete each lap of the race in shorter time and with lesser magnitude of increase in HR than their counterparts further supports the above contention.

Male runners also exhibit greater ability to accelerate in the last two laps of running than the female runners, which is indicative of high power possessed by them to liberate energy anaerobically to recruit a large number of muscle fibres for rapid body movements. Anaerobic capacity refers to the additional amount of energy that is not accounted for by the uptake of oxygen. It is dependent on the rate at energy is produced via the glycolytic pathway and is reported by many investigators to be well developed in sprinters and also in long distance runners capable of rapid acceleration in a relatively slow paced race (Newsholme, 1986 and Medbo et al., 1988). It can thus be concluded that male runners possess higher anaerobic threshold, better submaximal HR responses and greater ability to liberate energy anaerobically than the female runners and therefore perform better in the 3000m race.

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