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HEART RATE AND BLOOD LACTATE IN 400 M FLAT AND 400 M HURDLE RUNNING : A COMPARATIVE STUDY

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Abstract : This study was conducted on a group of male sprinters (n=8) to compare heart rate (HR) and blood lactate (La) response in 400 m flat and 400 m hurdle running during weekly trial race. Durations of the flat and hurdle races were 51.65 ± 1.51 and 58.27 ± 1.97 sec respectively. Peak HR attained at the end of the flat and hurdle races were 192.4 ± 5.3 and 193.6 ± 4.1 beats/min, whereas, average HR during the events were 173.6 ± 22.6 and 176.7 ± 19.6 beats/min respectively. La level following the flat event (18.84 ± 1.57 mmol/L) was found significantly ($P<0.05$) higher than the post-hurdle race (16.14 ± 1.97 mmol/L). The study indicates that cardiovascular stress is similar in both the events although flat race impose higher anaerobic glycolytic demand than hurdle run.

Key words : average heart rate peak heart rate blood lactate hurdle run flat run

INTRODUCTION

Hurdle races are track events that demand speed with maintained stride rhythm in an effort to cross the hurdles at regular intervals. In men's sports there are two hurdle events – 110 m and 400 m. Previous studies (1, 2, 3) have evaluated physiological demands of competitive running of various distances but physiological investigations on hurdle races are scanty. Beaulieu at al (3) studied La response in 110 m hurdles and 100 m flat running as a part of their investigations on a group of French decathletes during competition. Records from competitions of various levels indicate that a runner can compete successfully in both the events. There are some common aspects in both the events but the differences in training pattern also cannot be neglected.

The present study was conducted on a group of sprinters to compare heart rate (HR) and blood lactate (La) response during 400 m flat and 400 m hurdle running. Finding of any differences would be useful in preparation of training schedule.

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METHODS

Eight male sprinters were the subjects of this study. They were attending a pre-competition training camp at NIS, Patiala. Their age, height and weight were 22.1 ± 2.8 years, 172.3 ± 2.9 cm and 63.6 ± 3.8 kg respectively. All the athletes were experienced in participating in both 400 m flat and 400 m hurdle events in competitions. The athletes were informed in detail about the potential benefits and risks of this study before they agreed to participate.

The whole experiment was conducted in two stages. In the first stage VO_2 max was evaluated on treadmill (Venky, India) by graded exercise protocol (4). Maximum heart rate (HR_{max}) was considered as the highest HR attained at the end of most exhaustive stage of running. In the final stage HR were recorded by telemetry during 400 m hurdle and 400 m flat events when their weekly trial races were going on. At first the runners took part in the flat event. After an interval of 7 days they participated in the hurdle race. All the participats warmed up for 25 to 30 min before the start of each event. The races were conducted on a 400 m synthetic track, 4 hours after lunch.

Recording of HR

HR were recorded by telemetry (Sport tester PE-3000, Polar Electro, Finland) from start till 10 sec after the end of the races. The recording interval was 5 sec.

Collection of blood samples

Blood samples were drawn from the prewarmed fingertips and were collected three times on the day of each event: at rest, within 1 min after the end of warm up and 3 min after the completion of race. Precautions were taken to prevent dilution of blood samples by perspiration or tissue fluid (5). La were measured by an automated lactate analyzer (1500 Sport, YSI, USA).

Differences between the mean values were measured by paired t test. The acceptance level of significance, in all the cases, was set at $P<0.05$.

RESULTS

VO_2 max and HR_{max} of the runners were 62.3 + 3.2 ml/kg/min and 198.7 +3.9 beats/min respectively. Timings and HR of the athletes, attained in both the events, are presented in Table I. It also shows pre-exercise (anticipatory) HR of the athletes recorded just before (0 sec) the start of the events. The mean duration of hurdle race was 6.6 sec longer than flat running. All the runners, excepting R2 and R6, attained higher peak HR during hurdle event. Athletes' average HR during hurdle race was recorded higher, although not significantly, than flat event (excepting R4 and R6). No significant difference in pre-exercise HR was found between the events.

Figure 1 is the HR-time curve (mean) during flat and hurdle running. HR were slightly higher in hurdle run up to 10 sec from the start but after that no difference was observed till the end.

Pre- and post- race La levels following each of the events are presented in Table II. Post-race La were much higher than the respective warming up levels. La was found

TABLE I : Duration and heart rate attained in 400 m flat and 400 m hurdle running events.

Subject	Time (sec)		Pre-ex HR (beats/min)		Peak HR (beats/min)		Average HR (beats/min)	
	F	H	F	H	F	H	F	H
R1	51.21	57.20	128	136	192	197	176.2	184.2
R2	50.23	59.11	133	129	194	193	172.8	175
R3	52.27	56.32	119	124	189	192	168	174.9
R4	51.51	58.37	137	133	193	193	173.3	172.3
R5	49.72	57.45	129	121	186	188	171.5	174.5
R6	54.25	59.20	115	139	199	195	178.3	177.8
R7	53.16	62.25	141	135	200	201	177	180.3
R8	50.89	56.23	125	140	186	190	169.5	173.8
Mean + SD	51.65 +1.51	58.27 +1.97	128.4 +8.7	132.1 +6.9	192.4 +5.3	193.6 +4.1	173.6 +22.6	176.7 +19.6

F = 400 m flat
H = 400 m hurdle

TABLE II : Pre- and post- race blood lactate levels in 400 m flat and 400 m hurdle running.

Subject	Blood lactate (mmol/l)			
	Flat		Hurdle	
	Warm up	Post-race	Warm up	Post-race
R1	2.39	19.82	3.21	16.36
R2	2.98	20.70	4.42	19.93
R3	3.43	19.75	3.98	15.17
R4	3.21	18.40	4.06	17.69
R5	5.03	16.80	4.81	14.21
R6	4.98	20.32	4.26	15.02
R7	5.19	16.56	3.88	16.61
R8	3.36	18.38	3.73	14.11
Mean +SD	3.82 +1.08	18.84 +1.57	4.04 +0.48	16.14 +1.97

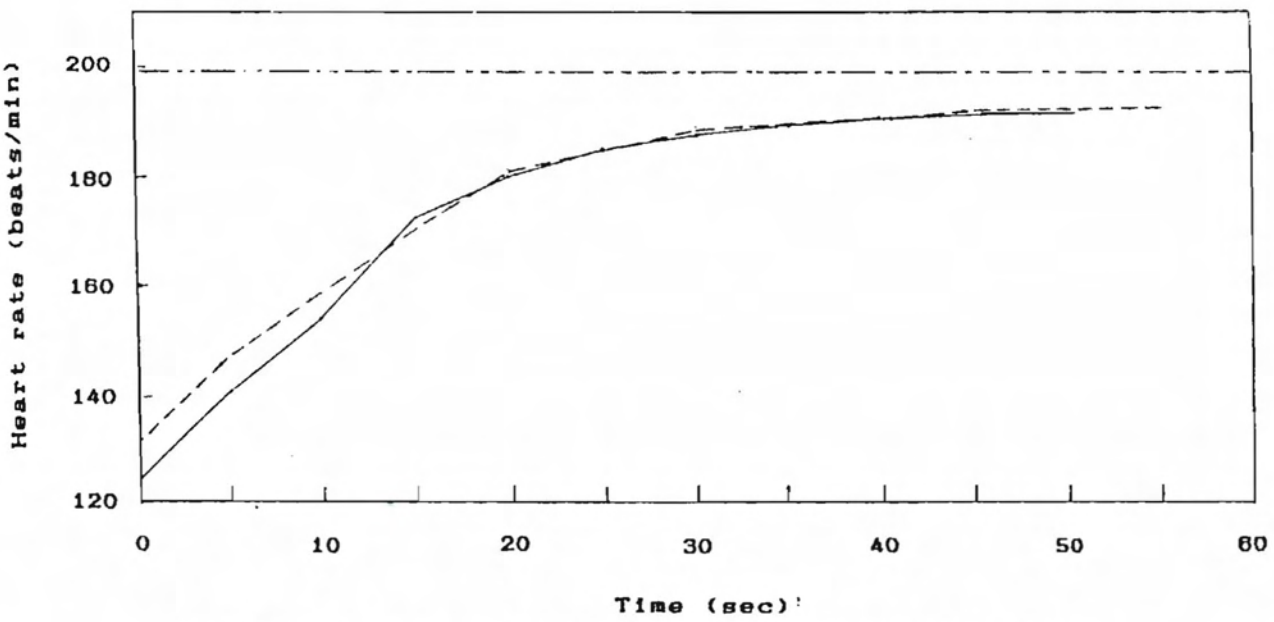

Fig. 1 : Heart rate recording (mean) during 400 m flat and 400 m hurdle running.
Maximum HR
Flat
Hurdle

significantly higher after the completion of flat running in comparison to hurdle race.

DISCUSSION

The VO2 max of the 400 m runners (flat and hurdle both) of the present study is comparable to the earlier reports on Indian athletes (4). So, the present runners could be considered as representative population.

Timings of the athletes, as recorded in this study, were very close to their personal best. Two athletes- R2 and R8, exceeded even their personal best in flat and hurdle event respectively. Thus all the runners ran with their maximal effort. Pre-exercise or anticipatory HR of the athletes were much higher (128.4 and 132.1 beats/min before flat and hurdle events respectively) than the resting HR values (78.2+4.9 and 73.4+5.7 beats/min respectively) as measured in erect posture before warm up. Although this higher heart rate can occur due to psychological reasons also, higher pre-exercise lactate level confirms a raised level of metabolic rate at the beginning of exercise. This rise was mainly due to a good level of warm up exercises carried out by the athletes. It has been shown that warm up augments local blood flow and aerobic metabolism in muscle during early phase of exercise (6). Conventionally heart rate is raised to about 140 beats/min during the warm up and athletes prefer to start the race before cooling down. So, essentially the oxygen deficit incurred due to a moderate level of work remains until the end of the race (full recovery). Higher starting HR also provides rapid mobilization of bodily reserves. This happens because of a smaller

difference between the oxygen consumption level required for the race to that of at the beginning of the exercise. Such effect has been described more helpful in sprint events than distance running (7, 8). Similar rise in HR before the flat and hurdle events is because of identical distance of run. The neural mechanism of this phenomenon was attributed to an increase in sympathetic discharge and reduction in vagal tone (8, 9). Conditioned reflexes from cerebral cortex may also initiate similar rise in pre-exercise HR (9). Besides sprint running, this phenomenon is also common in other anaerobic sports like gymnastics (10) and weight lifting (unpublished observations). Despite maximal efforts, peak HR were lower than their HR_{max} indicating that oxygen uptake remains at submaximal level in both the events.

Heart rate overshoot is a phenomenon linked with explosive human actions (10). A number of studies have shown that in activities involving Valsalva maneuoevre heart rate values shoot up after the end of activity. This overshoot has less link with the actual work load. It is possible that jumping over the hurdle caused HR overshoot and the effect was reflected in the average heart of 400 m hurdle race. Inspite of lower running speed, marginally higher HR in hurdle race may becuase of jumping over the hurdles.

It is not possible to achieve very high speed in hurdle race unlike flat running. In hurdle event an athlete requires to maintain stride rhythm to cross the hurdles with minimum interruption of speed. However, this reduces speed to some extent. In this study significant difference in running speed was found between the events could be due to reduction of speed. The average speed of the runners during hurdle race varied from 6.43 to 7.11 m/s with a mean value of 6.87 m/sec. The average speed was of 7.75 m/sec in flat running. Jumping over the hurdles provide a very brief rest pause and also reduces speed.

Lactate concentration in blood reaches peak value 2-4 min after the cessation of maximal exercise (5, 11, 12). So, blood sampling at 3 min after the end of 400 m running events is likely to reflect the peak La level in blood. The net La concentration in muscle and blood depends primarily on the intensity and duration of exercise (2, 13). Beaulieu et al (3) reported La level of 12.14 and 6.96 mmol/L following 100 m dash and 110 m hurdle respectively in 7 French decathletes during competition. In their study La following hurdle race was 57.3% of La as observed following 100 m dash. In the present study also relatively higher La was found in flat running than hurdles. It was shown that higher stimulation depleted glycogen to a greater extent in FT (pink and white both) muscle fibers (14). It is likely that higher speed in flat running causes rapid depletion of glycogen through anaerobic glycolysis and results in higher La.

Thus the study concludes that :

(a) higher average speed in 400 m flat race causes higher La in comparison to 400 m hurdle race most probably due to the effect of duration of running;

(b) cardiovascular stress is similar in both the track events;

(c) the design of training schedule should take this difference into account and give

more effort on developing the anaerobic qualities in 400 m runners.

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