

Physiological profile of Sri Lankan male long distance runners and sprinters competing at national level and university level; a descriptive study

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ABSTRACT

Introduction: Despite regular training Sri Lankan runners do not perform well in international sports arena. The performance of a runner is determined by cardiopulmonary fitness level. However, little is known about the cardiopulmonary fitness levels of Sri Lankan runners. Thus, the present study was conducted to assess the status of the cardiopulmonary fitness of a group of Sri Lankan national level and university level male long distance runners and sprinters.

Methods: A descriptive cross-sectional study was conducted to determine the baseline data using interviewer administered questionnaire and clinical examination of 95 male runners [national level long distance runners (n = 27), national level sprinters (n = 27), university level long distance runners (n = 20), university level sprinters (n = 21)] and age and sex matched control subjects (n = 41). Cardiopulmonary exercise fitness was assessed by a fully automated Cardiopulmonary Exercise Testing (CPET) machine.

Results: The CPET parameters such as VO_{2max} , peak workload, exercise duration, heart rate at rest (HR_{rest}) and at peak (HR_{peak}), systolic blood pressure at rest (SBP_{rest}), and at peak (SBP_{peak}), diastolic blood pressure at rest (DBP_{rest}), and at peak (DBP_{peak}) amongst Sri Lankan national level runners indicated minimal improvement when compared to Sri Lankan university level runners. Further, most of the CPET parameters of Sri Lankan runners were lower when compared with those parameters of runners from the Asian region.

Conclusions and recommendations: Cardiopulmonary fitness of Sri Lankan long distance runners and sprinters is low. Thus, training protocols are needed to be modified in accordance with the baseline CPET parameters to attain optimal cardiovascular remodelling to enhance the performance of Sri Lankan runners.

Key words: *Cardiopulmonary fitness, cardiopulmonary fitness assessment, running athletes, running performance.*

Introduction

The physical training and exercise promote functional and structural changes in cardiovascular system resulting in physiological modifications desirable for an athlete to give his/ her optimal performance. These changes are collectively known as cardiovascular remodelling. Cardiopulmonary exercise testing (CPET) is a widely accepted mode to determine cardiopulmonary response to training of athletes. Optimal cardiopulmonary fitness of an athlete indicates the integrated ability of the body to transport oxygen from the atmosphere to the mitochondria in muscles and remove the metabolic by-products from the active muscles during high intensity physical activity. Thus CPET parameters are dependent on a linked chain of processes that include pulmonary ventilation, diffusion of gases at the level of lungs and tissues, cardiac autonomic control, functions of the right and left ventricles (during both systole and diastole), the ability of the vasculature to accommodate and efficiently transport blood from the heart to active muscles and the ability of the muscle cells to receive and use the oxygen and nutrients delivered by the blood (1). Thus, CPET parameters comprehensively determine the function of the heart, the circulation and the respiratory system.

Maximal O₂ consumption (VO_{2max}) is a main CPET parameter which comprehensively describes the cardiopulmonary fitness level and it can be used to measure the adaptations of the runners to the training. Most important factors that influence the individual differences of VO_{2max} are the mode of exercise and the trained state of the body, body composition, heredity, gender, and chronological age (2).

A high VO_{2max} is a prerequisite for success in long-distance running performance. Endurance training of male and female runners engaged in long distance running events such as 10,000 m and marathon events, increases VO_{2max} by 10% - 25% compared to untrained sedentary people (3). The VO_{2max} of some professional marathoners have been reported as nearly as twice of the VO_{2max} of sedentary individuals (4). In contrast to endurance training, sprint runners will increase the VO_{2max} by 5% - 12% with training, compared to untrained people irrespective of gender (5).

Training results in an enhanced parasympathetic tone over the sympathetic activity on the heart. Thus, regular training results in adaptation of the heart; a major manifestation of the cardiac regulatory mechanisms (6). This effect is more pronounced in athletes engaged in endurance training as indicated by higher reduction in HR_{rest} as much as 43% when compared to untrained individuals (7). Well trained elite athletes with high endurance have significantly lower peak heart rates than the untrained individuals at a given VO_{2max} (8).

The blood pressure response may be detrimental to the exercise performance of athletes (9). As reported in literature, professional endurance runners have significantly lower resting blood pressure than normal people. Studies report a reduction in mean SBP_{rest} by 05mmHg and a reduction in mean DBP_{rest} by 03 mmHg after endurance training (10).

Considering the above background, the present study was conducted to assess cardiopulmonary fitness parameters amongst Sri Lankan athletes engaged in long distance running events (10,000 m and marathon) and sprinters (engaged in 100 m and 200 m running) in comparison with age, gender and height-matched controls. Since there is a paucity of CPET data on Sri Lankan runners, these values would be useful to guide training schedules of Sri Lankan runners to enhance their performance to reach international standards.

Methods

The study group consisted of 95 male runners; National Level Long Distance Runners (NLDR, n = 27), National Level Sprinters (NLS, n = 20), University Level Long Distance Runners (ULDR, n = 27), University Level Sprinters (USR, n = 21). National level runners competing at national and international level and university runners competing at Sri Lanka University Games were recruited into the study. Age, sex and height matched sedentary adults who were not attending in regular sports training were studied as control subjects (n = 41). Those who had past or present history of musculoskeletal injuries or chronic non communicable diseases were excluded from the study.

All participants gave informed written consent. They were assessed using an interviewer administered questionnaire to obtain baseline data and a full clinical examination including resting ECG to confirm general health before start the study. Height and weight were measured for the calculation of body mass index (BMI). Systolic and diastolic blood pressure were measured at rest and just after exercise.

Prior to conducting each test, the CPET machine was calibrated by using the calibration cylinder according manufacturer's guidelines. CPET for the runners and controls was carried out by using continuous incremental protocol (30W/minute) up to exhaustion (11) with electromagnetically braked cycle ergometer (COSMED, Italy). Real time gas analysis was conducted using a fully automated CPET machine (*Fitmate*TM, COSMED, Italy). The parameters assessed were VO_{2max} (ml/kg/min), exercise duration (minutes), exercise capacity (Metabolic Equivalents; METs), work load (W), heart rate at rest (HR_{rest}) and at peak (HR_{peak}) (beats.min⁻¹), systolic blood pressure at rest (SBP_{rest}) and at peak (SBP_{peak})(mmHg), diastolic blood pressure at rest (DBP_{rest}) and at peak (DBP_{peak}) (mmHg).

Ethical approval was granted for the study by the Ethics Review Committee of Faculty of Medical Sciences, University of Sri Jayewardenepura.

Statistical analysis

Data were analysed by using the Statistical Package for the Social Sciences (SPSS) version 20. Data were compared using ANOVA and Student's t-test.

Results

The mean values of age, height, weight, BMI and duration of training of NLDR, ULDR and controls are summarised in Table 1. The mean weight and mean BMI of male controls was significantly higher than the mean weight and mean BMI of NLDR and ULDR ($p < 0.05$). Even though the duration of training between NLDR and ULDR was similar ($p > 0.05$), NLDR were engaged in significantly higher number of training hours per week than the ULDR ($p < 0.05$).

The mean age, height, weight, BMI and duration of training of NSR, USR and controls are summarised in Table 2. The mean age, height, weight, BMI and duration of training were not significantly different between NSR, USR and controls ($p > 0.05$). The mean training hours per week of NSR was significantly higher than the USR ($p < 0.05$).

CPET parameters of national level runners, university level runners and controls are summarised in Tables 3 and 4.

Table 1: Age, anthropometry and training data of national level and university level long distance runners and controls

Baseline Characteristics	NLDR (n = 27) (Mean ± SD)	ULDR (n = 27) (Mean ± SD)	Controls (n = 41) (Mean ± SD)
Age (years)	23.7 ± 4.9	22.8 ± 1.3	23.0 ± 1.4
Height (cm)	168.0 ± 5.0	169.0 ± 6.3	169.6 ± 6.8
Weight (kg)	53.0 ± 3.0 ^{*?}	55.4 ± 7.1 [?]	64.0 ± 13.7
Body Mass Index (kg/m ²)	18.7 ± 1.0 ^{*?}	19.2 ± 2.13 [?]	22.0 ± 3.8
Training hours per week (hours)	16.8 ± 5.4 ^μ	9.4 ± 3.0	--
Duration of training (years)	5.0 ± 3.4	6.3 ± 4.1	--

ANOVA test and Student's t-test used to compare the means

μ - Significantly higher than university runners; * - Significantly lower than university runners; ? - Significantly lower than the controls
NLDR - National Level Long Distance Runners; ULDR - University Level Long Distance Runners

Table 2: Age, anthropometry and training data of national level and university level sprinters and controls

Baseline characteristics	NSR (n = 20) (Mean ± SD)	USR (n = 21) (Mean ± SD)	Control (n = 41) (Mean ± SD)
Age (years)	23.8 ± 3.2	22.5 ± 1.5	23.0 ± 1.4
Height (cm)	171.6 ± 6.5	173.8 ± 5.3	169.6 ± 6.8
Weight (kg)	65.1 ± 9.6	65.0 ± 13.1	64.0 ± 13.7
Body Mass Index (kg/m ²)	21.8 ± 2.2	21.8 ± 4.2	22.0 ± 3.8
Training hours per week (hours)	20.9 ± 7.7 ^μ	8.9 ± 4.2	--
Duration of training (years)	6.9 ± 3.3	5.9 ± 3.6	--

ANOVA test and Student's t-test used to compare the means

μ - Significantly higher than university runners; NSR - National Sprint Runners; USR – University Sprint Runners

Table 3: Cardiopulmonary fitness parameters of national level long-distance runners, university level long distance runners and controls

Parameter	NLDR (n = 27) Mean ± SD	ULDR (n = 27) Mean ± SD	Controls (n = 41) Mean ± SD
VO _{2max} (ml/kg/min)	58.2 ± 9.4 ^{μ¶}	50.6 ± 7.4 [¶]	37.4 ± 6.5
METs	16.6 ± 2.6 ^{μ¶}	14.4 ± 2.1 [¶]	10.9 ± 2.1
Exercise Duration (min.)	12.6 ± 2.0 ^{μ¶}	11.1 ± 1.2 [¶]	9.5 ± 1.1
Work load (W)	302.1 ± 79.4 ^{μ¶}	259.2 ± 39.5	223.8 ± 51.6
HR _{rest} (beats/min)	59.5 ± 12.9 ^{*?}	68.0 ± 10.2 [?]	78.6 ± 21.4
HR _{peak} (beats/min)	165.8 ± 12.1	169.7 ± 13.9	164.4 ± 19.7
SBP _{rest} (mm Hg)	120.0 ± 8.97	120.0 ± 10.76	123.57 ± 6.98
SBP _{peak} (mm Hg)	158.46 ± 13.48 ^{μ¶}	154.0 ± 8.94 [¶]	144.39 ± 8.38
DBP _{rest} (mm Hg)	70.0 ± 6.43 [?]	70.0 ± 8.32 [?]	80.0 ± 3.10
DBP _{peak} (mm Hg)	85.12 ± 5.06	83.0 ± 4.70	85.85 ± 4.98

ANOVA test used to compare the means

μ - Significantly higher than university runners; ¶ - Significantly higher than the controls; * - Significantly lower than university runners; ? - Significantly lower than controls; NLDR - National Level Long Distance Runners; ULDR - University Level Long Distance Runners

Table 4: Cardiopulmonary fitness parameters of national level sprinters, university level sprinters and controls

Parameter	NSR (n = 20) Mean ± SD	USR (n = 21) Mean ± SD	Controls (n = 41) Mean ± SD
VO _{2max} (ml/kg/min)	47.6 ± 8.4 [¶]	45.1 ± 6.4 [¶]	37.4 ± 6.5
METs	13.6 ± 2.4 [¶]	12.8 ± 1.8 [¶]	10.9 ± 2.1
Exercise Duration (min.)	12.8 ± 3.3 ^{μ¶}	10.9 ± 1.3 [¶]	9.5 ± 1.1
Work load (W)	285.6 ± 78.1 ^{μ¶}	269.2 ± 36.0 [¶]	223.8 ± 51.6
HR _{rest} (beats/min)	66.0 ± 10.3 ^{*?}	75.57 ± 15.2	78.67 ± 21.4
HR _{peak} (beats/min)	171.3 ± 12.5 [¶]	172.2 ± 11.6 [¶]	164.4 ± 19.7
SBP _{rest} (mm Hg)	123.31 ± 4.97	120.0 ± 14.76	123.57 ± 6.98
SBP _{peak} (mmHg)	157.50 ± 14.52 ^{μ¶}	151.0 ± 12.93 [¶]	144.39 ± 8.38
DBP _{rest} (mmHg)	70.40 ± 2.00 [?]	70.0 ± 6.97 [?]	80.0 ± 3.10
DBP _{peak} (mmHg)	85.60 ± 5.06 ^μ	81.5 ± 3.66 [?]	85.85 ± 4.98

ANOVA test used to compare the means

μ - Significantly higher than university runners; ¶ - Significantly higher than the controls; * - Significantly lower than university runners; ? - significantly lower than controls; NSR - National Sprint Runners; USR - University Sprint Runners

Cardiopulmonary fitness parameters

The mean VO_{2max}, METs (functional capacity), exercise duration on cycle ergometer and work load of NLDR were significantly higher when compared with ULDR and control subjects ($p < 0.05$). ULDR had significantly higher VO_{2max}, METs and duration of exercise in comparison to controls ($p < 0.05$). HR_{rest} was significantly lower amongst NLDR and ULDR than controls. HR_{peak} was not significantly different between runners and controls ($p > 0.05$). SBP_{peak} of NLDR and ULDR were significantly higher than that of the controls ($p < 0.05$). NLDR and ULDR had significantly lower DBP_{rest} compared to controls ($p < 0.05$).

The NSR had significantly higher exercise duration on cycle ergometer, work load than USR and controls ($p < 0.05$). However, the VO_{2max} level and METs of NLDR had no significant difference when compared with USR. HR_{rest} and HR_{peak} of NSR and USR were significantly lower than the

controls ($p < 0.05$). The mean SBP_{peak} of NSR and USR were significantly higher than the controls ($p < 0.05$). The mean DBP_{rest} of NSR and USR were significantly lower than the controls ($p < 0.05$). The mean DBP_{peak} of NSR and controls were significantly higher than the USR ($p < 0.05$).

Discussion

The purpose of this study was to determine the current status of CPET parameters of NLDR and NSR in comparison with ULDR, USR and controls. To the best of the authors' knowledge this is the first study conducted in Sri Lanka to assess the CPET parameters of national and university level runners using real time gas analysis.

In the present study, the age and the height were found to be similar between NLDR, NSR, ULDR, USR and control subjects. NLDR were found to

have the lowest body weight and BMI amongst national level runners, university level runners and controls. This may be due to the engagement of NLDR in regular endurance training than the other runners. The distribution of age, height, weight and BMI of Sri Lankan NLDR and NSR were found to be similar to available data of international long distance runners in the region (12).

In the present study, VO_{2max} of NLDR was lower than the international long distance runners in the region (12). Deficiencies of the endurance training programs including unavailability of high-altitude training may be a reason for the lower VO_{2max} level of NLDR. However, the mean VO_{2max} of NLDR was significantly higher when compared to the VO_{2max} of ULDR and the control subjects.

In the present study, NLDR had lower peak work load at the point of exhaustion during the CPET assessment compared to previously reported data of Asian runners (13). However, the peak work load of NLDR was significantly increased compared to the university counterparts.

In the present study, as expected, higher VO_{2max} level was observed in NSR and USR when compared to controls. The reason for the higher levels of VO_{2max} amongst NSR and USR than controls may be the lower cardiopulmonary fitness levels of physically less active controls.

Sri Lankan NSR had achieved the VO_{2max} on par with the data of international sprinters in the region reported in the literature (12, 14). However, the USR and NSR also had similar level of VO_{2max} .

The NLDR and NSR had significantly higher exercise duration on cycle ergometer, exercise capacity and peak work load along with the higher VO_{2max} when compared to ULDR and USR. When an athlete is engaged in regular training on selected groups of muscles, such as leg muscles for a longer duration of time it will cause an increase of VO_{2max} level and psychological tolerance to fatigue (15). Even though the national runners and the university runners were engaged in technical sports training for a similar duration; NLDR and NSR were engaged in significantly higher training hours per week than the university counterparts. The higher tolerance to fatigue achieved through longer training may be the reason for the significantly higher exercise

duration on cycle ergometer, exercise capacity and peak work load of national runners than the University runners. However, the peak work load of NSR is far below than the peak work load of elite Asian sprinters (16). As explained in literature, there is a strong positive correlation of peak power output and running speed of elite sprinters (17). As depicted by the present study, lower peak work load may be a reason for poor performance of NSR and USR.

NLDR had the lowest HR_{rest} whereas the NSR and had the highest HR_{peak} amongst the national runners, University runners and the controls. Earlier studies have reported that professional endurance runners had significantly lower resting blood pressure (SBP_{rest} and DBP_{rest}) than other people (10). In the present study, an isolated reduction of DBP_{rest} was observed amongst national and university runners which is in accordance with the available data of Asian elite long distance runners (18). However, no difference was observed of mean SBP_{rest} amongst the national and university runners when compared to the controls. Significantly higher mean SBP_{peak} was observed amongst national runners when compared with the university counterparts and the control subjects. This may be due to the higher exercise level and the higher tolerance of fatigue amongst national runners gained through comparatively longer duration of training.

The results of the present study indicate that sub optimal remodelling of the cardiovascular system had been attained by NLDR and NSR irrespective of the rigorous training when compared to university counterparts. However, as depicted by lower HR_{rest} and DBP_{rest} of NLDR, the parasympathetic effect of training was pronounced amongst long distance runners when compared to sprinters and controls.

Conclusions

The present study concludes that lower levels of cardiopulmonary fitness parameters such as VO_{2max} and peak power output of Sri Lankan national long distance runners may be detrimental to optimal performance at international arena. Although Sri Lankan sprinters achieved similar VO_{2max} as reported amongst international sprinters, lower peak power output is a major limiting factor

of performance. Suboptimal remodelling of the cardiovascular system is the main reason for the lower level of cardiopulmonary fitness of Sri Lankan long distance runners and sprinters. Training protocols are known to contribute to cardiovascular remodelling. Thus, training protocols need to be modified in accordance with the base line CPET parameters to attain optimal cardiovascular remodelling, and thus enhance performance.

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