RESEARCH ARTICLE

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Assessment of Physiological Profiles in Developing Norms for Cardiopulmonary Fitness for Sri Lankan Rowers

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ABSTRACT

Measurement of maximum oxygen consumption at tissue level (VO2 max) using cardiopulmonary exercise testing (CPET) is considered the gold standard in evaluating physiological fitness of an athlete. No such testing had been conducted on Sri Lankan national level rowers up to date. With this background the aim of this study was to evaluate the physiological profile of national rowers of Sri Lanka to assess the state of their cardiopulmonary fitness.

Anthropometrical and physiological profiles were created for 22 rowers (10 males and 11 females). The Shapiro-Wilcoxon test was used to check the normal distribution. Means and standard deviations of the parameters were calculated. A P value less than 0.05 was considered to be statistically significant.

Twenty rowers achieved more than 90% of their predicted HR and one achieved a HR of more than 85% indicating a maximum effort by the entire group. The average work rate achieved by oarsmen were 231 W, which is an average of 82% of the predicted. The average HR achieved was 187 BPM, which corresponds to an achievement of 96% of the predicted. The average respiratory exchange ratio achieved by oarsmen were 0.96, an indication of anaerobic glycolysis at peak exercise. Oarswomen achieved a peak workload of 235 which is slightly more than oarsmen. This is an achievement of 81% of the predicted. The group average HR achieved by oarswomen was 95 BPM, which is an achievement of 95% of the predicted. The group average RER was 0.84 which indicates a mixture of aerobic and anaerobic glycolysis at peak exercise.

The VO2 values obtained by Sri Lankan rowers are low compared to international standards. Despite the overall lower VO2 max obtained by male rowers, their VO2 at AT was at a higher percentage of their peak VO2, indicating better cardiovascular fitness. Cardiovascular exercise can be improved to achieve a higher VO2 with a lower HR through threshold training in order to improve performance and uplift the stranded of rowing in Sri Lanka.

Keywords: cardiopulmonary exercise testing, cardiopulmonary fitness, physiological profiles, Sri Lankan rowers.

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I. Introduction

A. CPET to Measure VO_{2Max} (Maximal Oxygen Consumption)

Use of Cardiopulmonary Exercise Testing (CPET) to measure VO_{2Max} is the gold standard for assessing an individual's cardiopulmonary function and providing information for the design of individualized training regimes (Balady *et al*., 2010). A CPET requires participants to push their bodies to the limit, typically providing more accurate measurements of aerobic capacity. Maximal Oxygen Uptake is considered as the primary assessment tool commonly used in the assessment of cardio-pulmonary fitness among endurance athletes (Losnegard & Hallén, 2014). The results are widely used in the selection of athletes for national and international events and to assess the training level and selection process of the players. In previous studies, a positive correlation between $VO_{2\ max}$ and high performance has been demonstrated (Coyle, 1999) been demonstrated, indicating the importance of the assessment of maximal aerobic capacity among endurance athletes on regular basis.

B. Rowing in Sri Lanka

Rowing is a sport with a high demand on the cardiopulmonary system utilizing both aerobic and anaerobic pathways to produce energy (Nevill *et al*., 2011), (Mäestu *et al.,* 2005). This demonstrates the

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level of aerobic capacities among rowers is a key determinant of performance (Mäestu *et al*., 2005). The regular examination of anthropometric and physiological parameters in international rowing competitors has made them successful in their competitions (Mikulić & Ružić, 2008).

Maintenance of individual physiological profiles is considered as an effective tool of detection of strengths and weaknesses of an individual player, determining heart rate for threshold training and to measure the peak oxygen utilization (VO_{2max}). Although rowing was established in Sri Lanka 150yers ago, no real time cardiopulmonary exercise testing (CPET) has ever been done on Sri Lankan national level rowers up to the current study, leading to lack of physiological parameters available for coaches and selectors alike. The lack of these baseline physiological parameters among individual Sri Lankan rowers could be identified as one of the key attributors to poor performance. Furthermore, the lack of bassline data has negatively affected the recruitment process and the formation of the Sri Lankan rowing pool and choosing the final team to represent the country at international level. To fill this gap in literature and considering the need to establish baseline norms as a national requirement, we aim to assess the physiological profiles of rowers and establish norms relevant to the physiological parameters for national level Sri Lankan rowers.

II. Materials And Methods

A. Study Setting, Inclusion Exclusion Criteria and Experimental Protocol

The study was conducted at the Institute of Sports Medicine, Ministry of Sports, and Youth Sri Lanka and at General Sir John Kotelawala Defence University (KDU). Ethical clearance was obtained through the ethical review committee of KDU (RP/2022/38). All the players who were pooled in the Sri Lankan rowing federation was included in the study. Participants with upper or lower limb musculoskeletal, neurological, and other injuries within the last two weeks as confirmed by a diagnosis card, participants who have undergone any surgeries within the previous six months or rowers under medical advice not to participate in vigorous or any other physical activity and players with known cardiorespiratory condition (Exercise-induced asthma, Asthmatic attacks) were excluded from the study. A total of 21 rowers (oarswomen n=11, oarsmen n=10) were recruited. The demographic data is presented in Table I.

Anthropometrical data (height, Weight, BMI) was calculated prior to commencement of CPET. All the participants conducted an incremental exercise test until exhaustion on the Concept II rowing ergometer at an increasing increment of 50 W/min. Participants were encouraged to continue exercises as long as possible to obtain the most accurate VO_{2Max} measurement. Throughout the test participants were asked to breathe through a facemask which continuously sampled the inspired and expired air using a bidirectional pitot tube flow sensor (BLT, Cardiopoint, USA). During the exercise heart rate (HR) was continuously monitored.

B. Data analysis

Respiratory compensation point (RCP) and aerobic threshold (AT) was identified by an experienced physiologist and a Sports Physician using the methods used by him and published in (Senanayake *et al*., 2020). Firstly, the point of upward inflection of the Ve curve was identified. Then the point of gradual increase in ventilatory equivalent for oxygen ($Ve/\dot{V}O_2$) occurred with a reduction in the ventilatory equivalent for carbon dioxide ($Ve/\dot{V}CO_2$) was identified as the AT. This was confirmed by the V slope method. Microsoft excel, Cardio point software and SPSS were used for the statistical analysis. During the statistical analysis of the data the means and standard deviations of the parameters were calculated. The Shapiro-wilk test was used to check the normal distribution of data.

III. Results

The anthropometrical data obtained for both oarsmen and oarswomen are given in Table I bellow. The total sample size was 21 with oarsmen (n=10) and oarswomen (n=11).

TABLE I: Anthropometric Measurements of the Subjects

Variables	Average Anthropometric Measurements	
	Oarsmen (n=10)	Oarswomen (n=11)
Age	25.20±5.77	24.36±3.83
Height (cm)	174.90±11.88	168.0±5.55
Weight (cm)	66.20±15.50	61.55±6.64
BMI (kg/m^2)	21.41±3.54	21.78±1.92

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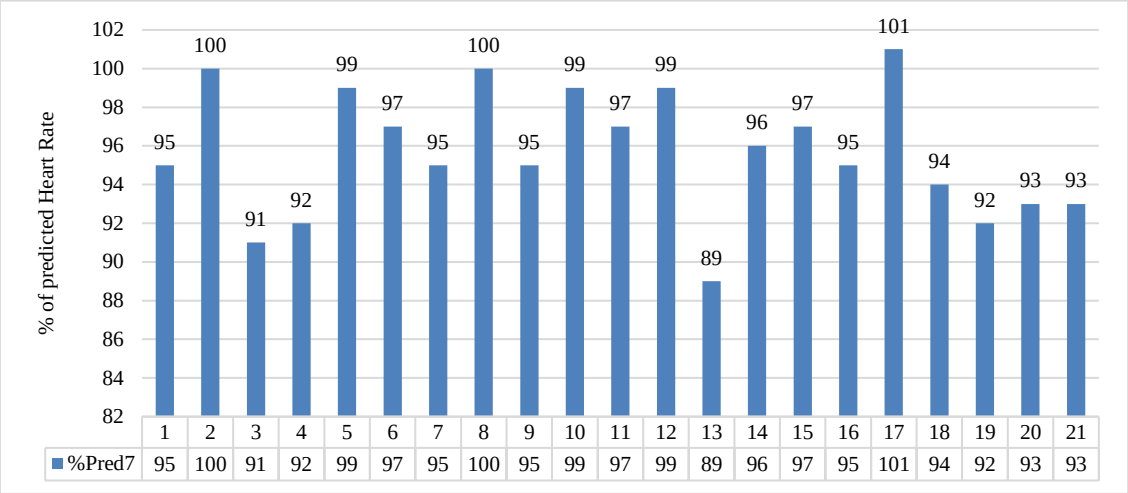

Fig. 1. Individual percentage of predicted heart rate reached.

Twenty rowers achieved more than 90% of their predicted HR and one achieved a HR of more than 85% indicating a maximum effort by the entire group. Three subjects were able to reach their maximum Heart Rate. The Highest value was achieved by an oarswomen participant whereas other two were achieved by oarsmen (Fig. 1 above).

TABLE II: AVERAGE PHYSIOLOGICAL PARAMETERS OBTAINED FOR CPET BY ROWERS

Variables	Oarsmen (n=10)			Oarswomen (n=11)		
	Maximum values achieved	Percentage of the Predicted achieved	Achievement at anaerobic Threshold	Maximum values achieved	Percentage of the Predicted achieved	Achievement at anaerobic Threshold
Workload (W)	231.60±52.18	82.10±15.05	190.30±62.14	235.73±67.32	81.37±9.9	114.82±16.98
VO_2 (L/min)	2226.30±648.62	76.70±13.45	1528.40±574.87	1902±550	87.55±25.10	1312.55±539.69
VO_2 (ml/min/kg)	36.23±13.10	76.70±13.45	31.22±9.13	30.43±8.73	87.55±25.10	21.02±7.68
VO_2/ HR (L/min)	11.48±3.74	85.00±13.17	12.45±3.31	10.55±2.81	95.45±27.77	9.05±2.72
VCO_2 (ml/min/kg)	2179.60±582.88	61.27±19.74	1578.70±576.28	1696.27±521.73	53.50±19.74	1042.36±466.81
VE (L/min)	127.14±21.88	85.70±12.28	80.23±27.52	98.28±28.44	81.36±19.29	54.24±26.85
HR (Beats/min)	187.50±9.77	96.30±3.29	163.30±26.18	185.91±6.76	95.09±3.40	150.64±22.55
RER	0.96±0.19	NA	0.78±0.10	0.84±0.28	NA	0.78±0.10

Average physiological parameters obtained for CPET by rowers are given in Table II above. The average work rate achieved by oarsmen were 231 W, which is an average of 82% of the predicted. The average HR achieved was 187 BPM, which corresponds to an achievement of 96% of the predicted. The average respiratory exchange ratio achieved by oarsmen were 0.96, an indication of anaerobic glycolysis at peak exercise. Oarswomen achieved a peak workload of 235 which is slightly more than oarsmen. This is an achievement of 81% of the predicted. The group average HR achieved by oarswomen was 95 BPM, which is an achievement of 95% of the predicted. The group average RER was 0.84 which indicates a mixture of aerobic and anaerobic glycolysis at peak exercise.

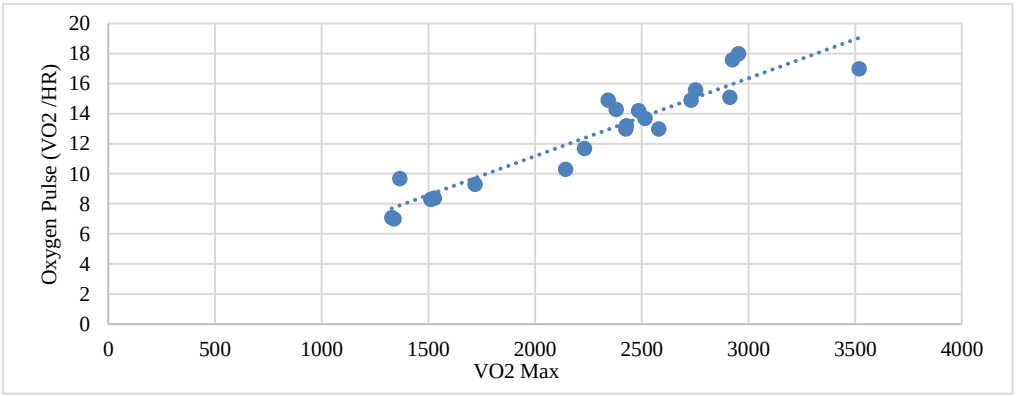

Fig. 2. Maximum oxygen uptake vs Oxygen Pulse.

A strong positive correlation was found between maximum oxygen uptake vs oxygen pulse (0.967 p=<0.01), (See Fig. 2).

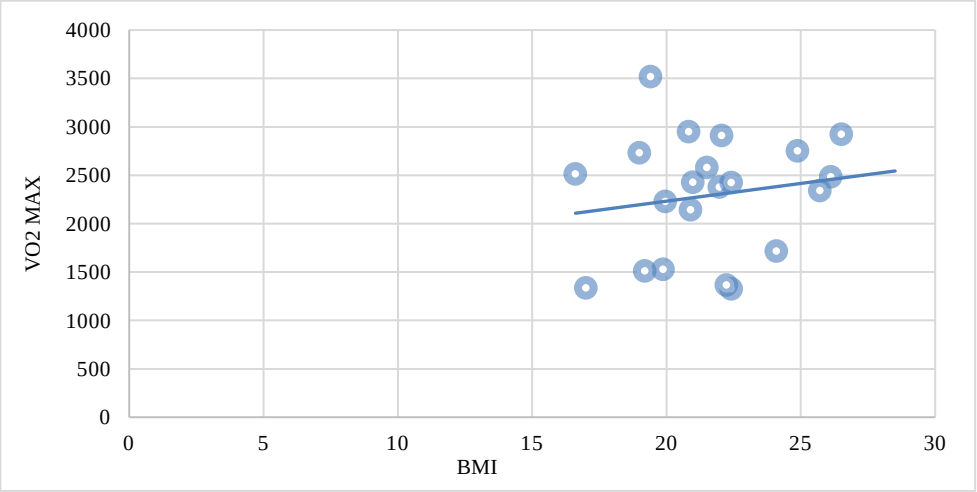

Fig. 3. Maximum oxygen uptake vs BMI of the subjects.

Non-significant negative correlation (-0.351 p=0.119) was found in the maximum oxygen uptake vs BMI of the subjects (See Fig. 3).

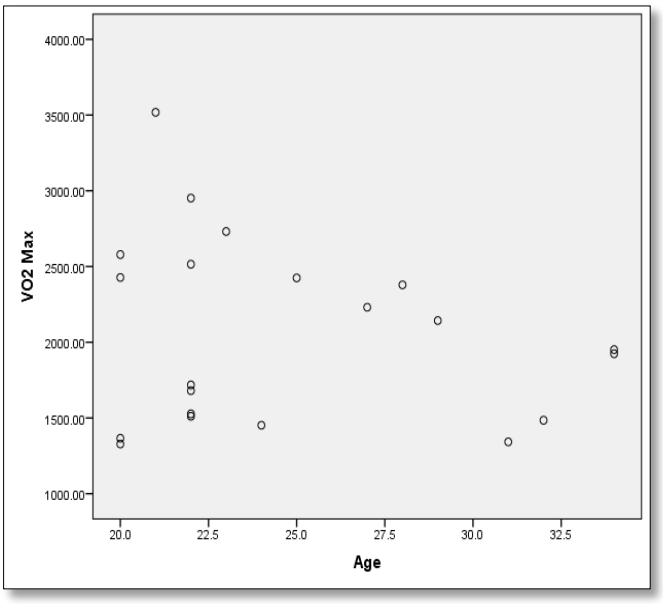

Fig. 4. Age vs VO_2 Max.

All the participants over 30 years had achieved less VO2 Max values (See Fig. 4).

IV. Discussion

To the best of our knowledge this is the first study conducted in Sri Lanka to assess the cardiopulmonary fitness of rowers using real time breath by breath analysis (gold standard). The results of CPET are dependent on maximum effort. Heart rate (HR) is one of the factors which determines this (Lee *et al*., 2022). HR can also be used as a parameter to assess the fitness of the cardiovascular system in response to exercise (Lee *et al*., 2022). It is required to achieve at least 80% of the predicted HR to qualify as a maximum effort (Glaab & Taube, 2022). Twenty participants achieved this and once achieved 89% of the predicted indicating a maximum effort and a good cardiovascular response to exercise. Despite this only three rowers managed to achieve 100 % of the predicted HR and three more achieved 99% of the predicted.(Fig. 1)

Average $VO_{2\ max}$ values obtained by oarsmen were 36.23 ml/min/kg (87.5 % of the prediction of VO_2) and oarswomen achieved an average of 30.43 ml/min/kg (76% of the predicted). Despite the greater achievement of percentage of predicted, the VO_2 at anaerobic threshold (AT) was 21.02 ml/min/kg for oarswomen, which is 69% of the $VO_{2\ max}$. Oarsmen achieved 86% of the $VO_{2\ max}$ at AT. The peak VO_2 obtained by oarsmen was 44.7 ml/min/kg whereas females achieved a peak VO_2 of 39.1 ml/min/kg. Studies

published with reference VO_2 values for rowers are limited. A study conducted by Klusiewicz *et al*., 2014 on polish rowers shows that oarsmen in the age group of 21–22 have a peak VO_2 value of 60 ml/min/kg and oarswomen had a peak of 53 ml/min/kg. This clearly demonstrates the low VO_2 values Sri Lankan rowers obtained compared to international level. This could be mainly due to lack of scientific insight in determining anaerobic thresholds when conducting their training regimes leading to blind training.

Both the groups showed good oxygen delivery to muscle with an oxygen pulse (VO_2/HR) at 85% of the predicted for oarsmen and 95% of the predicted for oarswomen. This greater percentage of oxygen delivery could be attributed to the better VO_2 max achieved by the oarswomen of the study group as evident in Table II.

Respiratory Exchange Ratio (RER) is the most used secondary end criterion for determining $VO_{2\ max}$ (Howley *et al*., 1995). But the average RER of the present study for oarsmen was 0.96 at peak exercise and 0.84 for oarswomen which is lesser than the originally recommended secondary end criterion (RER≥1.15) (Issekutz *et al*., 1962) which could be a result the younger age sample. Numerous studies have shown that aerobically trained athletes show a lower RER value during strenuous exercise compared to non-trained people (Ramos *et al*., 2008) (Bergman *et al*., 1999). This is because endurance training increases mitochondrial activity and lipid metabolism (Sahlin, *et al*., 1998), (Short, 2003).

Some recent studies have shown that there is a negative correlation of BMI with VO_{2max} values. A study conducted by Huldani *et al*, on Indonesian general population concludes that males with higher abdominal circumference and BMI has significantly lower VO_2 values. Our results showed a non-significant negative correlation between BMI and $VO_{2\ max}$ values (Fig.3). This could be due to less participants in the study but the individual $VO_{2\ max}$ levels were poor in all the participants who are above 22 BMI level which is in par with the findings of (Auliadina, 2019). This could be a result of difficulty for the movements with high BMI and the inhibition of oxygen uptake due to excess fat of the participants of our study.

Strength and weakness

All rowers who took part in the study were from the Sri Lankan national rowing pool. This allows us to get the rowers who can give the best physiological response to exercise leading to an increase in the quality of data obtained. The number of oarswomen and oarsmen included in the study are roughly equal. The smaller sample size could be a weakness of the study, which might be the possible reason for statistically non-significant correlations we observed.

V. Conclusion

The VO_2 values obtained by Sri Lankan rowers are low compared to international standards. Despite the overall lower VO_2 max obtained by male rowers, their VO_2 at AT was at a higher percentage of their peak VO_2, indicating better cardiovascular fitness. Cardiovascular exercise can be improved to achieve a higher VO_2 with a lower HR through threshold training in order to improve performance and uplift the stranded of rowing in Sri Lanka.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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