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Relationship of Competitive Success to the Physique of Sri Lankan Rowers

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Abstract **Background:** The anthropometric profile is considered to be one of the most important determinants of competitive success in any type of sport. The aim of this study was to investigate the association between anthropometric profile with the competitive success in rowing ergometer performance, aerobic fitness & anaerobic fitness in professional rowers in the Sri Lanka Army. **Method:** A cross sectional descriptive study was conducted to assess the anthropometric profile, aerobic fitness, anaerobic fitness and ergometer performance in 32 male and 14 female professional rowers in the Sri Lanka Army in the age range of 20-33 years. Body weight, body height, waist circumference, hip circumference, leg length, arm span, skin fold thickness and arm circumference were measured using a weighing scale, skin fold caliper and measuring tape while the body mass index was calculated. Performance was assessed by the 2000m rowing ergometer test time while aerobic fitness was assessed by the volume of maximum oxygen consumption. The peak power and power average were calculated to measure anaerobic fitness by using the vertical jump test. **Result:** The mean values for rowing ergometre time for male and female were 7.07 and 8.36 minutes respectively. Rowing ergometre time negatively correlated with body height ($p=0.02$) lean body mass ($p=0.049$) and body mass index in male rowers ($p= 0.028$) and body height ($p=0.021$), leg length ($p=0.008$), body mass ($p=0.02$) and arm span ($p=0.025$) in female rowers. Aerobic fitness negatively correlated with body weight ($p=0.01$), arm circumference ($p=0.01$), skin fold thickness ($p=0.01$), fat mass ($P=0.01$) and lean body mass ($p=0.049$) in male rowers and body mass index ($p= 0.02$) and fat weight ($p=0.049$) of female rowers. Anaerobic fitness significantly correlated (negatively) with the 2000m rowing ergometer test time ($p= 0.001$) and positively with body height ($p=0.02$), Leg length ($p = 0.04$) and arm span ($p=0.04$) of male rowers. **Conclusion:** This study shows that there is a significant association between the anthropometric profile, performance and aerobic and anaerobic fitness of Sri Lankan rowers. Rowers with a larger stature, longer leg length and arm span, less body fat and greater total muscle mass performed better at rowing ergometer. Rowers with high anaerobic power performed better at rowing ergometer. Higher anaerobic power was observed in rowers who were taller with larger arm span and leg length while rowers with a lower body weight, lesser arm circumference, lower skin folds, lower fat weight, greater total muscle mass possed better aerobic fitness.

Keywords: *anthropometric profile, rowing ergometre, aerobic fitness, anaerobic fitness*

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1. Introduction

The anthropometric profile of an athlete can be considered to be one of the most important determinants of successful performance in a sport. The specific physique traits associated with competitive success vary with the specific sports [1]. Several studies have shown the relationship between competitive success and the anthropometric profile of different sports such as track and field events [2], Judo [3], soccer [4], swimming [5] and light weight [6] and heavy weight rowing [7]. It has been shown that judo players with a higher percentage of body fat correlated negatively to performance in activities involving body mass locomotion [3] while young soccer players from successful teams were found to be leaner and more muscular than their unsuccessful counterparts [4]. Swimmers, track athletes, and rowers were observed to be taller than others in their age group during childhood and maintained their position relative to reference data during childhood and adolescence [8]. A rowing specific anthropometric profile has been shown to be an important factor for successful performance in rowing in addition to the skill and experience of the rower [9,10]. Anthropometric data for adult male and female rowers underlined the importance of body weight ([7,11,12]) and body size ([6,13,14,15]) in determining successful rowing performance at an international level. Rowers performed better when they are taller ([16,17,18,19]) heavier [11] with long extremities [16] and had lower skin fold values

[19] than less successful competitors. Successful gold medalists were found to be taller and heavier than the other competitors [7]. Muscle mass has been shown to be an important determinant of competitive success [6,20] and performance has been shown to be positively correlated with muscle mass amongst both junior [21] and senior heavy weight rowers [17,22]. A well developed aerobic and anaerobic energy systems are required in array of sports such as team hand ball [23], Judo [3], soccer [24] and rowing [9,10]. Competitive rowing is an endurance type of sport and requires a well developed aerobic [10] and anaerobic capacity [9]. The energy requirement for competitive rowing is 65-75% aerobic and 25-35% anaerobic [25,26]. The aerobic power or cardiovascular endurance assesses the athlete's maximum oxygen uptake which directly influences the performance of the rower [27,28] and it is important for a rower to perform prolonged, large muscle, dynamic activities at moderate to high levels of intensity during rowing while anaerobic power is especially important during the initial spurt and final dash [11]. Several studies have shown that aerobic and anaerobic capacity correlate with performance [29] and the anthropometric profile of rowers ([9,10,20]). Several studies have reported a significant correlation between the 2000 m ergometer rowing results and VO2max values ([19,30,31,32]) while some researchers reported that power at the anaerobic threshold intensity is the most predictive parameter of competition performance in trained rowers ([20,33,34]). It has been shown that there is a strong association between lean body mass and lower body weight with aerobic capacity in rowers [35] and elite heavyweight rowers possess the highest aerobic capacity values ([11,29,33]) and the effects of physical structure and anaerobic capacity during rowing performance should not be underestimated [35].

The aim of the present study was to determine the anthropometric profile of Sri Lankan rowers in view to improve the competitive success of the rowers in relation to performance and fitness so that the sport of rowing in Sri Lanka could be developed to international standards. This would also be invaluable for future talent identification and the establishment of development programs in rowing in Sri Lanka.

2. Materials & Methods

2.1 Subjects

The study group consisted of 46 healthy rowers in the Sri Lanka Army between the ages 20 – 33 years. The sample consisted of 32 male and 14 female rowers. All the players were selected for the study using convenient sampling method and participants provided written informed consent prior to testing. Ethical clearance was obtained from the Ethics Review Committee, Faculty of Medicine, University of Peradeniya. Sri Lanka.

2.2 Anthropometric Profile

Full anthropometric profile was measured as body weight, skin fold thickness at 5 sites, body height, arm circumference, leg length, arm span, waist and hip circumferences. The skin fold thickness was assessed at 5 sites (triceps, suprailiac, abdomen, thigh and chest) using harpenden caliper. Body mass was assessed in minimal clothing on a calibrated digital scale with a precision of ±0.02 kg. The circumference of upper limb (from upper one third of length from the acromio-clavicular joint to the olecranon), circumference of the hip (at the level of the anterior superior iliac spines), the waist (at the level of the navel), the length of the legs (from the greater trochanter to the lateral malleolus), arm span (from the left to the right dactylion) and body height (from the flat floor to top of the person head) were measured using non-elastic measuring tape. The mean of duplicates or median of triplicate anthropometric variables was used for all subsequent analyses.

2.3. Performance

The 2000 m rowing on-water testing for assessing rowing performance is difficult to carry out; therefore concept II rowing ergometer is used (in a controlled widely laboratory environment) as it provides accurate estimates of a rower's physiological ability of power output, and some submaximal and brief maximal ergometer performance [31,38]. The time spent on rowing ergometer machine was measured. However, it has been argued that a 2000 m time trial on an ergometer may not reflect the metabolic demands of on-water rowing [39] especially in smaller boats where it takes significantly less time to complete the effort on an ergometer than on water [23].

2.4. The Aerobic Fitness

The Multi-Stage Fitness Test (MSFT) was developed to monitor the development of the player's maximum oxygen uptake [38]. Before the test, the player was asked to warm up for 10 minutes followed by a 20m run in time with a beep from a CD recording. The assistant recorded the level and number of shuttles completed by the player when they are withdrawn. The player’s maximum oxygen uptake (VO_2 max) was determined from the MSF table using the Level and Shuttle achieved [38].

2.5. The Anaerobic Fitness

In the present study, the anaerobic power was assessed using the standing vertical jump test which is the most common field test can be used to evaluate anaerobic fitness [39]. The player was asked to jump as high as possible from a standing position. Jump height was recorded as a distance score using a measuring tape [28]. The peak power and power average were calculated to measure anaerobic fitness.

2.6. Statistical Analysis

The SPSS 17 version for Windows statistical software package was used to compute and report the data. Descriptive statistics were used to describe and summarize the measurements of performance, aerobic and anaerobic fitness and anthropometric characteristics. Multiple regressions were used to identify significance correlation among anthropometric characteristics and rowing performance, aerobic, anaerobic fitness to the various. It was considered that there was a significance association if the p value was less than 0.05 ($p<0.05$).

3. Results

In total 32 male and 14 female rowers in the Sri Lankan army team participated in this study. Table 1 shows the mean values of the anthropometric profile of female and male rowers. Both male and female rowers are in overweight category according to the BMI scale [28] and they are in marginal level in waist to hip ratio. But, it is interesting to note that both male and female rowers having recommended amount of fat percentage according to the international standards [28].

Table 1. Mean values of Anthropometric profile of professional male and female rowers.

Anthropometric profile	Mean ± SD	
	Male	Female
Body mass (Kg)	69.57 ± 8.61	67.13 ± 11.06
Body height (cm)	177.87± 2.66	164.87± 2.52
Leg length (cm)	95.01 ± 2.11	92.16± 1.98
Arm span (cm)	187.84 ± 3.99	168.45± 3.10
Arm circumference (cm)	29.05 ± 1.12	26.94± 0.90
Body Mass Index (BMI)	23.26 ± 4.41	23.61 ± 5.59
Waist/ Hip	.98 ± 1.06	.823± 0.72
Skin fold thickness (mm)	26.58± 10.56	61.66± 13.67
Fat weight (kg)	5.11 ± 2.91	18.22± 6.65
Lean body mass (kg)	62.55 ± 5.69	48.91± 10.6

SD= Standard Deviation.

Two thousands meters (2000m) rowing ergometer test time for male and female was 7.07 min (range 6.48-7.59min) and 8.36 min (range 8.06 to 9.02min), respectively. As shown in Table 2 rowing ergometre time negatively correlated with body height (p=0.01), lean body mass (P=0.049) and body mass index in male rowers (p= 0.028) and body height (p=0.02), leg length (p=0.01) and arm span (p=0.02) in female rowers but fat weight did not correlate with the rowing ergometre performance (p>0.05).

Table 2. The correlation between 2000m rowing ergometer time and anthropometric characteristics of professional rowers

Anthropometric profile	Mal Correlation(r) (p value)	Female Correlation(r) (p value)
Body mass (Kg)	-0.22 (0.23)	-0.95 (0.02)*
Body height (cm)	-0.57 (0.02)*	-0.98 (0.01)*
Leg length (cm)	-0.33 (0.12)	-0.95 (0.02)*
Arm span (cm)	0.04 (0.44)	0.05(0.02)*
Arm circumference (cm)	-0.52 (0.03)*	0.56 (0.21)
Body Mass Index	0.31 (0.028)*	0.01 (0.49)
Waist/ Hip	0.25 (0.19)	-0.76 (0.11)
Skin fold thickness (mm)	0.311 (0.14)	0.868 (0.049)*
Fat weight (kg)	0.01 (0.49)	0.009 (0.49)
Lean body mass (kg)	-0.38 (0.04)*	-0.763(0.11)

*p<0.05- significance

The aerobic and anaerobic capacity of male and female rowers is shown in Table 3. The mean values for the volume of maximum oxygen consumption (VO2 max) for male and female was 42.6 ml/kg/min and 28.2 ml/kg/min, respectively. According to the international standards; the aerobic capacity of female rowers was "Very poor" while in male rowers (42.6 ml/kg/min) it was in the "Fair" category [28]. The relationship between various anthropometric profiles and the aerobic / anaerobic capacity is shown in Table 4. The aerobic fitness significantly correlated (negatively) with body weight (p=0.01), arm circumference (p=0.01) and skin fold thickness (0.01) of male rowers while in female rowers it was the body mass index (p= 0.02). The anaerobic fitness significantly correlated positively with body height (p=0.03), leg length (p=0.04) and arm span (p=0.04) in male rowers.

There was no significantly correlation between aerobic capacity and 2000m rowing ergometer time in both male and female rowers (p>0.05) as shown in Table 4. The anaerobic fitness significantly correlated negatively with 2000m rowing ergometer time (p=0.00) though both male and female rowers in the present study performed "Poorly' for the vertical jump test (48.7cm & 26.2cm respectively) according to the international standards [28].

Table 3. Mean values of aerobic and anaerobic fitness of male and female rowers

Fitness characteristics	Male (Mean ± SD) N= no of players	Female (Mean ± SD) N= no of players
Aerobic fitness (ml/kg/min)	42.6 ± 7.13 (N= 19)	28.2 ± 4.33 (N= 07)
Anaerobic fitness		
Peak power (W)	4300 ± 566.6* (N= 32)	3674.6 ± 628.2 (N= 14)
Avg power (W)	-297.75 ± 295.9 (N= 32)	-534.9 ± 327.8 (N= 14)

SD= Standard Deviation
*p<0.05- significance.

Table 4. The correlation between aerobic and anaerobic fitness to the anthropometric characteristics of male & female rowers

Anthropometric characteristics	Aerobic fitness		Anaerobic fitness	
	Male Correlation (p value)	Female Correlation (p value)	Male Correlation (p value)	Female Correlation (p value)
Ergometre time	-0.04 (0.44)	0.02 (0.48)	-0.80 (0.001)*	-0.808 (0.00)
Body weight	-0.62 (0.01)*	-0.73 (0.13)	0.23 (0.21)	0.52 (0.24)
Body height	-0.03 (0.45)	-0.18 (0.40)	0.51 (0.03)*	0.29 (0.35)
Leg length	0.02 (0.46)	-0.02 (0.48)	0.42 (0.04)*	-0.13 (0.43)
Arm span	-0.12 (0.33)	-0.02 (0.48)	0.41 (0.04)*	-0.23 (0.38)
Arm circumference	-0.62 (0.01)*	-0.20 (0.40)	0.02 (0.47)	-0.31 (0.34)
Body Mass Index	-0.35 (0.11)	-0.94 (0.029)*	0.20 (0.23)	0.30 (0.34)
Waist/ Hip	0.08 (0.38)	-0.14 (0.42)	-0.15 (0.30)	0.73 (0.13)
Skin fold thickness	-0.64 (0.01)*	0.07 (0.46)	-0.18 (0.26)	-0.44 (0.28)
Fat weight	-0.67 (0.01)*	-0.89 (.049)*	-0.14 (0.30)	0.18 (0.49)
Lean body mass	-0.42 (0.049)*	-0.63 (0.18)	0.37 (0.09)	0.53 (0.24)

*p<0.05- significance.

4. Discussion

Anthropometric traits have been used extensively to predict performance outcomes and selection of athletes in different categories of sports. In the present study, the anthropometric characteristics were assessed to see the aerobic and anaerobic fitness and the performance of rowers of Sri Lanka in view to enhance their competitive success in the sport in the future.

The present study shows that body height correlates significantly with rowing ergometer performance in both male and female rowers while of leg length and arm-span correlated with rowing performance in female rowers which surprisingly was not seen in male rowers. The results are consistent with previous studies ([17,18,19,35]) that show that the rower's height and leg length and arm span [9] correlate to rowing performance. This is important in rowing as power is achieved through increased length of leverage on the oar through longer limbs of the rower. Long levers of the arms and legs are important to obtain maximum propulsion to increase a biomechanical advantage in rowing [2]. Tall rowers are able to make long rowing strokes [12] and long stroke lengths are closely correlated with high-level rowing performance [31].

The body mass of female rowers in the present study correlate well with performance which was again not seen among male rowers. The gold medalists were consistently heavier than the other competitors; in the event of the single sculls, the particular variances were significant 0.12m and 9.6kg, respectively [7]. In rowing, body mass is typically supported by a sliding seat in the boat or on a rowing ergometer, and large individuals possess an advantage ([11,12,39]).

Body fat weight in the present study did not correlate with rowing performance. A high body fat content has been found to adversely affect the 2000 m rowing ergometer performance [11,31] and the body fat content has been shown to vary according to the season for lightweight rowers [40].

Several studies have been designed to predict the best performance parameters for rowing [31,34]. It has been identified that lean body mass is an important anthropometric characteristic which strongly correlates with performance. The present study showed that lean body mass significantly correlated with 2000m ergometre test time of male rowers. This corresponds to past studies that show that performance correlates closely to the lean body mass [19,30]. Australian lightweight rowers with greater total muscle mass were associated with faster 2000m heat times and this is thought to be due to an association between the lean body mass, blood volume and stroke volume of the heart [1].

When aerobic and anaerobic fitness results were taken into account, important relationship with various anthropometric characteristics were noted. Aerobic fitness negatively correlated arm circumference, skin fold thickness, body weight, fat mass and lean body mass in male rowers and body mass index and fat mass of female rowers. Anaerobic fitness significantly correlated positively with body height, Leg length and arm span of male rowers. These findings are consistent with a previous study [9] which showed the large volume of aerobic training undertaken, together with weight training provides a rower with a high aerobic power, enhanced skill and metabolic efficiency, low skin folds and a greater muscle mass [35]. it also showed the importance of physical structure and anaerobic power for better rowing performance. This finding is supported by previous studies that have shown that elite heavyweight rowers posses the highest aerobic capacity values ([11,29,33]).

It has been established that overall power in rowers depends on their aerobic and anaerobic energy supplies balanced by the efficiency of their technique [41]. In the present study, 2000m rowing ergometer time did not correlate significantly with aerobic fitness but it correlated significantly with anaerobic fitness. This is in contrast to past studies ([17,27,35]) showed that absolute VO_2 max was the best predictor of 2000m simulated rowing performance and one important fitness component for the competitive success in rowing [42,43] but according to the Mikulic, [10] VO2max may not correlate well with performance among a relatively homogeneous population of endurance athletes. Several studies have reported that power at the anaerobic threshold intensity is the most predictive parameter of competitive performance in trained rowers ([20,33,34]). One of the reasons for the poor performance in rowing ergometer of the Sri Lankan rowers may be because they did not achieve international standards [28] in aerobic fitness.

5. Conclusion

Therefore we can conclude that Sri Lankan rowers who are taller , having longer leg length & arm span, less body fat and greater total muscle mass performed better at rowing ergometer and had better aerobic and anaerobic fitness. But the study also showed that the rowers were unable to achieve international standards in rowing. This could be due to other physical and physiological factors which affect the performance of the rowers. It has been shown that both anthropometric and metabolic parameters, such as body mass, sum of skin folds, oxygen uptake (VO2max), anaerobic capacity, blood lactate thresholds and exercise economy have been properly established for the performance prediction for different sports as road cycling [44], track cycling [45] and distance running [46]. In the sport of rowing, Russell, [20] has concluded that anthropometric factors or a combination of somatic and physiological variables may be more effective in predicting of 2000 m rowing performance than any single variable.

Therefore, we can conclude that the physique of Sri Lankan rowers associates well with competitive success in rowing in relation to performance and aerobic and anaerobic fitness.

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