Relationship between Physical Fitness, Performance and Injury Prevalence in Sri Lankan Rowers

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Abstract- As a rower requires optimum physical fitness and adequate technical skills for maximum performance the aim of this study was to assess the physical fitness of Sri Lankan rowers, in view to improve performance and prevent injury in the future. The sample consisted of 46 rowers of the Sri Lanka army sports unit. Health related physical fitness components were assessed using standard tests and equipment. Performance was assessed by 2000m rowing ergometer test, cardiovascular endurance and vertical jump. An interviewer administered questionnaire was used to obtain information of injury patterns. The mean values for rowing ergometer time for male and female rowers were 7.07 and 8.36 minutes respectively. Rowing ergometer time negatively correlated with anaerobic fitness, lean body mass and flexibility in male rowers while it was not significant in females. Aerobic fitness negatively correlated with fat mass in both male and female rowers while anaerobic fitness did not correlate with any fitness components. The injury prevalence was 68.8% and 57.1% in male and female rowers respectively. Therefore, although the Sri Lankan rower's physical fitness characteristics for flexibility and body composition correlated well with performance, most of the other physical fitness characteristics were not comparable to international standards in rowing.

Index Terms- Rowing, physical fitness, ergometer performance, aerobic fitness, injury

I. INTRODUCTION

Rowing is categorized as a speed sport and known to be the most physically demanding of all endurance sports [1]. Rowers generate tremendous muscular force to maintain an "all out" effort during the 2000 meter race which lasts between five to seven minutes [2]. It also requires a combination of technical skills, motor coordination, physical fitness, cardiovascular endurance [3,4,5] and anaerobic fitness [6]. For a sportsman to achieve competitive success in any sport an adequate level physical fitness should be achieved. This would also help in preventing sports related injury. Different sports require that physical fitness components namely body composition cardio-respiratory endurance, muscular strength, muscular endurance and flexibility are developed to certain levels to achieve international standards [7]. Physiological testing is commonly used to assess the overall fitness level of the athletes [8]. Physical fitness has been assessed in an array of sports including hand ball [9,10], Judo [11], Soccer [12,13], Athletics [14] including rowing [6,15]. The energy demands for rowing are high [2, 3,16,17,18]. Studies have shown that aerobic fitness positively correlates with the rower's 2000 meter performance [2,6,19-23]. Anaerobic power has been shown to be especially important in the first and last quarter of the race which are known to be the fastest [3,6,17,24]. Other fitness components such as muscular endurance and strength are vital in back support and core stability of rowers [25,26]. Strengthening of the body core has been shown to improve performance in rowing [27-29]. Lack of lower body and back muscle endurance and strength have been shown to reduce the performance of rowers during rowing ergometer [1,30] but, literature on the subject is limited. The weak muscles of the back, [30-33] abdominal and lower limb [4,34-36] are associated with lower back pain of rowers. Limitations in flexibility of the hamstrings and joint hyper-mobility also lead to the development of low back pain and reduce the performance of rowers [37-41]. The body composition of a rower has also been shown to be an important determinant of performance [21,42-44]. The body mass [3, 45,46] and lean body mass [19,47,48] has been found to positively correlate with ergometer performance. A high body fat content has been found to adversely affect the performance [3,22]. Studies have shown that there is a strong association between aerobic capacity and lean body mass and lower body weight of rowers [2,3,16,20]. Although many studies have been carried out on physical fitness of rowers internationally, little information is available concerning the physical fitness characteristics of Sri Lankan rowers.

Therefore the aim of the present study was to assess the physical fitness characteristics of Sri Lankan rowers in view to improve the performance of the rowers so that the sport could be developed into an internationally recognized level in the future. This information could also aid in planning and modification of training programs and competitive tactics and help in preventing rowing related injury.

II. METHODS

Subjects:

Forty six healthy rowers in the Sri Lanka army sports unit between the ages 20 -33 years were selected for the study using convenient sampling method. The sample consisted of 32 male and 14 female rowers. Written informed consent was obtained prior to testing. An interviewer administered questionnaire was administered to obtain information about the demographic data and injury patterns of the rowers. Ethical clearance was obtained from the Ethics Review Committee, Faculty of Medicine, University of Peradeniya, Sri Lanka (2014/EC/45).

Data collection:

Physical fitness:
The Multi-Stage Fitness Test (MSFT) developed by Leger and Lambert was followed to monitor the rower's maximum oxygen

uptake [7]. This was also used to assess the performance of the rowers. The curl up test was used to measure abdominal strength and endurance. Rower's hand grip strength was assessed using the "Hand Grip Dynamometer". Flexibility was tested by using the Sit-and-Reach test. Skin fold values were taken with the use of a "Harpenden Skin fold Caliper" and measurements were taken from 3 specific sites for men (abdomen, thigh and chest) and women (triceps, suprailiac and thigh). All the techniques, test procedure and measurements for the multi-stage fitness test, curl up test, hand grip strength, sit and reach test and skin fold values were made based on the procedures given by Thomas et al., [7] and the values was compared with the normative data tables [7]. The fat percentage was compared with normative data given by Jackson and Pollock [49,50]. Fat percentage and body weight were used to calculate the lean body mass.

Performance in rowing:

The concept II rowing ergometer machine was used to measure performance of rowers in a controlled laboratory environment. The stop watch was used to measure the time duration to complete the 2000 meter distance. The anaerobic power was assessed using the standing vertical jump test which is the widespread field test that can be used to evaluate anaerobic fitness [51] and peak power and power average were calculated to assess the anaerobic fitness.

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 and physical fitness characteristics. Multiple regressions were used to identify the correlation among physical fitness characteristics and rowing performance. p value of less than 0.05 ($p<0.05$) was considered as a significance association.

III. RESULTS

In total 32 male and 14 female rowers in the Sri Lankan army team participated in this study. The mean age of male and female rowers was 23.7±3.03 and 23.43±2.10 years and the mean value for rowing ergometer time for male and female rowers as 7.07 and 8.36 minutes respectively. Table 1 shows the mean values of fitness characteristics of male & female rowers; namely aerobic fitness (42.6, 28.2ml/kg/min), muscular strength (47.1, 26.7kg), flexibility (58.7, 57, 2cm), fat mass (05.1, 18.2kg) lean body mass (69.58, 67.15kg) Muscular endurance (43.5, 33.3) peak power (4300w, 3674.6w) and power average (-297.75, -534.9) respectively.

Table 1: Physical fitness characteristics of male & female rowers:

Fitness characteristics	**Male (Mean ±SD) N= no of players**	**Female (Mean ±SD) N= no of players**
Body composition:		
-Body mass (Kg)	69.6± 8.61 (N=32)	67.2±11.06 (N=14)
-Fat mass (Kg)	05.1 ± 2.91 (N= 27)	18.2 ± 6.65 (N= 14)
-Lean body mass (Kg)	62.6 ± 5.69 (N= 26)	48.9 ± 10.6 (N= 14)
Cardiovascular Endurance (Aerobic Fitness) (ml/kg/min)	42.6 ± 7.13 (N= 19)	28.2 ± 4.33 (N= 07)
Muscular strength -Combined hand grip strength(Kg)	47.1 ± 6.24 (N= 28)	26.7 ± 5.82 (N= 14)
Muscular endurance -Curl ups test	43.5 ± 5.96 (N= 30)	33.3 ± 6.62 (N= 12)
Flexibility -Sit & Reach test (cm)	58.7 ± 5.66 (N= 32)	57.2 ± 7.30 (N= 12)
Anaerobic Fitness(w)		
-Peak power (w)	4300 ± 566.6***** (N= 32)	3674.6 ± 628.2 (N= 14)
-Average power (w)	-297.75 ± 295.9 (N= 32)	-534.9 ± 327.8 (N= 14)

SD= Standard deviation

The correlation between 2000 meter rowing ergometer time and the physical fitness characteristics of male & female rowers is shown in Table 2. Two thousands meter rowing ergometer time correlated negatively with anaerobic fitness ($p<0.01$), lean body mass ($p<0.05$) and flexibility ($p<0.05$) in male rowers while in female rowers there was no significant correlation with any fitness components ($p>0.05$).

Table 2: Correlation between 2000m rowing ergometer time and the physical fitness characteristics of male & female rowers

Fitness components	Male Correlation (r)	Female Correlation(r)
Body mass	-0.21	-0.95 *
Fat mass	0.25	0.01
Lean body mass	-0.42*	-0.76
Grip strength	-0.30	-0.49
Muscular endurance	-0.33	-0.15
Flexibility	-0.41*	-0.69
Anaerobic Fitness	-0.81**	-0.01
Aerobic Fitness	0.04	0.03

*p<0.05- significance
**p<0.01- highly significance

The relationship between the fitness characteristics and the aerobic capacity is shown in Table 3. Aerobic fitness correlated significantly with body composition (fat mass) of both male and female rowers ($p<0.05$). There was no significant correlation between anaerobic fitness and any of the fitness components in both male and female rowers ($P>0.05$).

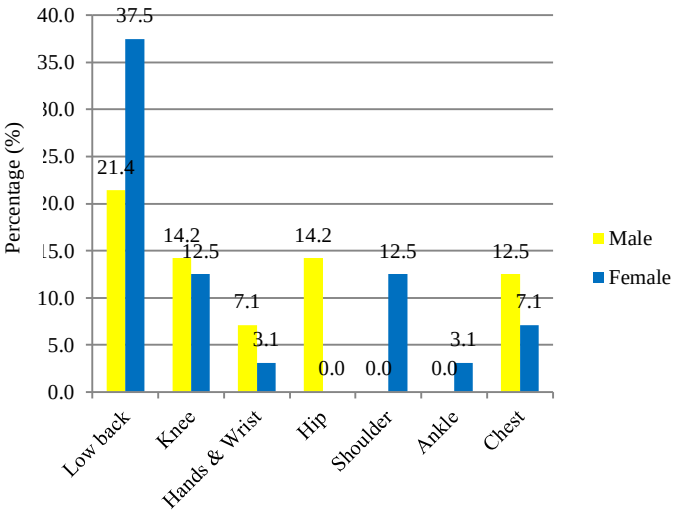
Table 3: The correlation between aerobic fitness and physical fitness characteristics of male and female rowers

Fitness components	Correlation (r) male	Correlation(r) female
Body mass	-0.22	-0.95*
Fat mass	-0.67**	-0.89*
Lean body mass	-0.42	-0.63
Grip strength L	-0.25	-0.84
Grip strength R	-0.21	-0.68
Muscular endurance	-0.14	0.48
Flexibility	-0.05	-0.20
Vertical jump	0.12	-0.60

*p<0.05- significant
**p<0.01- highly significance

Figure 1 shows the prevalence of injury which was 68.8% and 57.1% in male and female rowers respectively. The type of injury observed for male and female rowers were lower back pain (37.5%,21.4%), knee pain (12.5%,14.2%), hand and wrist pain (3.1%,7.1%), hip pain (0.0%,14.2%), shoulder pain (12.5%,0.0%) and ankle pain (3.1%,0.0%) respectively.

Figure 1: Prevalence of injury among male and female rowers:



IV. DISCUSSION

Physical fitness characteristics have been used widely to predict the performance characteristics of different sports. The primary finding in the present study was that the health related physical fitness of the Sri Lankan rowers did not achieve international standards. Therefore this study will be a stepping stone to achieving competitive success in the sport in the future. The findings would also provide trainers with information as to which physical attributes need to be improved to tailor fitness programs according to specific needs of the individual and also prevent injury. When the physical fitness component of body composition was considered both male and female rowers in this study possessed a "Recommended percentage of fat" (Table 1) according to international standards [7]. It also showed that lean body mass significantly correlated with 2000 meter ergometer test time in male rowers ($p<0.05$) which corresponds to other studies [21,45]. It was also interesting to note that fat mass and lean body mass of male rowers in the present study were better compared to some studies [6,12]. But, fat mass of the male rowers did not correlate with rowing performance. Possessing a high body fat content has been found to adversely affect the 2000 meter rowing ergometer performance [3,22]. The body mass of female rowers in the present study correlated well with rowing ergometer performance ($p<0.05$) which was not observed among male rowers. It has been shown that rowing gold medalists were consistently heavier than the other competitors in single sculls events [52]. During rowing, the body mass is typically supported by a sliding seat on the rowing ergometer machine and large individuals have been shown to possess an advantage in rowing [3,46,47,53]. Fat mass and lean body mass of male rowers negatively correlated with aerobic fitness while in females it was only fat mass. These findings were consistent with a previous study by Firat, [6] showed that the large volume of aerobic training undertaken, together with weight training provides a rower with a high aerobic power, enhanced skill, metabolic efficiency and a greater muscle mass [20]. Other studies have also shown that elite heavyweight rowers possess the highest aerobic capacity values [2,3,16].

The aerobic capacity or cardiovascular endurance of female rowers was "Very poor" according to international standards while in male rowers it was in the "Fair" category [7]. There was also no significant correlation between aerobic capacity and 2000 meter ergometer performance in both male and female rowers ($p>0.05$). But, studies have shown that when aerobic fitness and rowing performance were taken in to account absolute VO2 max was the best predictor of 2000 meter rowing performance [19,20] as 65-75% of the energy requirement for rowing is estimated to be from aerobic sources [6].

It has been shown that the first quarter of the race is the fastest, followed by the last quarter while the second and third quarters are the slowest [3]. Anaerobic power is thought to be specifically important during this initial spurt and final dash of a 2000 meter race [3]. Both male and female rowers in the present study performed "Poorly' for the vertical jump test according to the international standards [7] but the values of the male rowers were similar to a study done by Singh [25]. But there was a significant negative correlation between anaerobic fitness and 2000 meter rowing ergometer time ($p<0.05$) in male rowers. The finding is similar to study done by Riechman, [54] with the Wingate test machine which showed a statistically significant correlation between the Wingate rowing anaerobic test results and 2000 meter rowing ergometer performance. But, Steinacker, has suggested that there is a critical level of strength and anaerobic

capacity above which further improvements will not increase rowing performance [16]. The vertical jump test also measures lower body power and several studies have shown that lower body and lower leg muscles should be strengthened as all major muscles in lower limbs are used in the sport of rowing [1]. Poor performance on the vertical jump show the lack of lower body power of the Sri Lankan rowers which may be one of the reasons for poor performance.

Sri Lankan rowers achieved a good score for flexibility which was comparable to international standards [7] which also showed a significant negative correlation with 2000 meter rowing ergometer time ($p<0.05$) in male rowers. Though literature on the importance of flexibility in rowing performance is rather limited it has been shown that flexibility of rowers is an important component in achieving the correct positioning during the stroke cycle in rowing [37]. Lack of hamstring and hip flexibility may predispose rowers to back and knee injuries due to an increase in flexion strain in the lower back during sitting and reaching movements during rowing [4,41,42]. A high percentage of rowers in this study suffered from low back pain followed by knee pain (Figure 1). It has also been proposed that short hamstring length may be a risk factor for low back pain [38-40]. It has been suggested that 10 minutes of stretching after training may reduce the incidence of acute injuries [55] but; Howell, reported that rowers performing regular hamstring stretches had a high incidence of low back pain (LBP) [56]. Therefore further studies are required to determine the role of hamstring flexibility in low back pain in rowers.

Rowers have to generate a tremendous muscular force to maintain "all out" effort during the 2000 meter race [2]. Approximately 70% of the skeletal muscle tissue in the rower's body has been shown to be used in a single stroke cycle while successful rowers have been shown to have more slow twitch fibres [16]. Though the major muscles involved in rowing are the muscles of the lower limb and trunk, all muscles in the body including arm, forearm and wrist should be strengthened for better performance [1]. In the present study, both male and female rowers were in the "very poor" category for muscular endurance and "need to improve" category in muscular strength according to international standards [7]. Both physical fitness components did not correlate significantly with 2000 meter rowing ergometer time, aerobic or anaerobic fitness which was comparable to a study by Singh [25]. Several past studies have shown that the strengthening of the core body and limbs is required to improve performance in rowing [27- 29] as the pulling force is accomplished by the extensors of the lower extremities and trunk, and the flexors of the upper extremities during the drive phase of the stroke [26]. Long durations and years of endurance training have been shown to increase the number and diameters of slow twitch fibres, increase the oxidative enzymes and increase the mitochondrial number of elite rowers [2,3]. But according to Secher, rowing performance and strength data do not correlate well as the movements involved in rowing sport are specific [3]. Studies have also shown that the lower leg muscles and back muscles of rowers fatigue easily during ergometer rowing contributing to poor performance [1,30].

There are several studies which show that the lack of muscle strength and endurance of back, [30-33] abdominals and lower limbs [4,34-36] may predispose to the development of low back pain in rowers. Both male and female rowers in the present study had a high prevalence of low back injuries (Figure 2). One of the reasons for the poor performance of Sri Lankan rowers may due to inadequate muscles strengthening and endurance training. In comparison to the males, female rowers did not achieve international standards in physical fitness characteristics except for flexibility. Therefore, in female rowers, 2000 meter rowing ergometer time did not correlate to any of the above fitness components.

V. CONCLUSION

This study concludes that although the Sri Lankan rowers physical fitness characteristics for flexibility and body composition correlate well with performance, most of the other physical fitness characteristics were not comparable with rowing specific performance to achieve international standards in rowing. The study also confirmed that rowers with lower fat mass and lower body mass possessed higher aerobic capacity while those with higher anaerobic power associated better with rowing ergometer performance. This study highlights the importance of regular fitness training to achieve world standards for rowing, specifically in the areas of muscular strength, muscular endurance and cardiovascular endurance. Regular fitness assessments are also required to monitor training improvements and to determine which areas are best to concentrate on individually. This was one of the first studies to be conducted in rowers in Sri Lanka and we hope to continue to assess and improve the standards required to achieve competitive success in the future.

ACKNOWLEDGEMENT

The authors would like to acknowledge all members of the Sri Lankan army rowing teams, team coach and in charge of rowing for their support and collaboration during the study.

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