Relationship of Anthropometrics and Fitness Level Between Elite and University Male Rowers

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Abstract Successful competitive performance is particularly associated with four main characteristics which are skills, anthropometrics characteristics, appropriate psychological attitude, and physical fitness of individual athletes. Prior to that, selection of athletes for a particular sport should focus on those traits and abilities which have the most significant impact on sport performance. Hence, the purpose of this study was to determine the relationship between anthropometrics and fitness level among rowers. It consisted of one hypothesis as there was no statistical significant relationship on anthropometrics and fitness level among elite and university male rowers. Thirty male rowers (elite = 15, university = 15), aged 20–30 years, participated in this study. The design of this study was an ex post facto design. The method involved quantitative assessment of anthropometrics (height, weight, body fat percentage, body length, breadth, and girth) and fitness level tests (flexibility, power, relative strength, muscular endurance, and aerobic fitness). The findings showed significant positive relationship between nine of the anthropometrics measurements, which were height ($r = 0.76$), sitting height ($r = 0.65$), arm span ($r = 0.64$), arm length ($r = 0.73$), forearm length ($r = 0.54$), thigh length ($r = 0.74$), leg length ($r = 0.63$), shoulder breadth ($r = 0.43$), and calf girth ($r = 0.55$) with all fitness level variables among the elite and university rowers in this study. It can be concluded that anthropometrics and fitness level have a strong relationship toward rowers' performance.

Keywords Anthropometrics · Fitness level · Elite rowers · University rowers

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1 Introduction

Rowing has recently become a sport for talent identification. In selection of athletes for a particular sport, biomechanical and kinesiological investigations into the technical performance of rowers are rare and coaches depend on the overall mentality of technique [15]. It has been established that no single parameter measures physical fitness and that variable composite factor was involved in each sport. Thus, physical fitness may contain a number of different elements including maximal oxygen uptake, local muscle endurance, muscle strength, and body composition [8].

Elite athletes in sports such as rowing differ in physical and physiological characteristics. The researcher may expect the elite athlete to represent an expression of genetic, physical training, nutrition, and sociocultural factors. As an Olympic sport, rowing requires technique, tactics, and a high level of physical fitness and body size which are undoubtedly performance-related factors [6, 20, 21, 23]. Some of the physical fitness and anthropometrical variables are considered as requisites for high performance in rowing competition.

The performance achievements of Olympic athletes come from a unique mixture of features and capabilities developed by way of training. Determining factors such as physical size and framework which may result in the best performance can assist the exercise researcher and physical trainer in choosing and creating skilled athletes [1].

In selection of athletes for a particular sport, the focus should be on those attributes and capabilities which have the most significant impact on sports performance, such as physiological and anthropometric characteristics [15]. In the sport of rowing, skill recognition programs have attempted to identify potential young athletes using various performance factors, including several anthropometric data gathered at Olympic Games level to accomplish this skills recognition strategy. The latest extensive anthropometric study of rowers was conducted at the Sydney Olympic Games in 2000 [1].

Physical structure is an important factor that contributes to success in rowing [23], and evidences indicate that anthropometric characteristics have influenced over rowing performance [7]. Indeed, rowing is a type of strength–endurance game, challenging high stages of both aerobic and anaerobic capabilities for effective performance by approximately 70–80 % aerobic and 20–30 % anaerobic [11].

Instead of having a good fitness level, the rowing motion is also reinforced by the sliding seat so that the drive phase is sequentially conducted by extension of the legs and extension of the trunk with simultaneous flexion of the arm [12, 21]. The rower has to attain a mixture of high action power and maximum stroke length to produce an effective stroke [12]. Strength enhancement not only has an impact on speed and power but also provides the basis for strength endurance [14]. Having excellent anaerobic and aerobic capacity, strength, and power are the most important elements needed to achieve great results in rowing competitions [14, 21].

Previous research had investigated some of the anthropometric features such as height, lean body weight, and limb lengths in rowing athletes [4, 13, 17, 24]. These studies showed that elite's rowers are usually taller and heavier than athlete in other sports. However, if rowers' anthropometric details are only used as talent identification at all stages, past details provide only restricted details and more knowledge is required on the anthropometric characteristics of the elite rowers from the other country. Therefore, the aim of the present research was to determine the preliminary database of anthropometric and physiological profiles between Malaysian elite and university male rowers.

A review of the literature showed that most studies on rowing profiling have been conducted abroad [3, 4]. These studies also showed that elite rowers are usually taller and heavier as compared to other athletes. Since rowing has been played at the Olympic level, athletes must have an excellent fitness level such as flexibility, power, strength, muscular endurance, and a good aerobic capacity to win in tournaments. A strong and specific training program based on the individual needs to be designed in order for the athletes to excel in the games. However, in Malaysia, there is lack of adequate profiling data among the elite and local university male rowing athletes.

Thus, it is important for the athletes and coaches to know anthropometric characteristics and fitness level of elite and university rowers in order to design a training program or for talent identification. Hence, the aim of the present study was to get baseline data of local elite and university male rowers. This profiling will enable us to relate the elite and university male rowers' performances as a track record in view of the fact that we need to prepare subelite athletes to ensure continuous success.

2 Methodology

2.1 Participants

The sample consisted of 30 male rowers. Malaysian elite male rowers and university male rowers aged 20–30 years were selected for this study. The participants of elite and university rowers only consisted of 15 people in each group. Prior to the intervention, all participants completed their Prior to the intervention, all volunteers completed their screening. The study was approved by the Ethics Committee of MARA Technology University (600-RMI: 5/1/6/01).

2.2 Outcome Measures

Precisely, the variables measured were anthropometrics measurements (height, weight, body fat percentage, body length, breadth, and girth) and fitness level (flexibility (Flx), power (Pwr), relative strength (R.S), muscular endurance (M.E), and aerobic fitness (A.F)) to determine the relationship between anthropometric and fitness levels among the participants. The anthropometrics measurements were performed according to the ISAK manual [12] by two testers who had taken part in using Harpenden Anthropometer, USA. Meanwhile, eight sites of skindfold to determine the body fat percentage by using the Harpenden Clipper equipment.

The flexibility was measured by sit and reach test, while power was measured by vertical jump test. Moving on to strength, it was measured by handgrip and leg dynamometer test. Next is muscular endurance which was estimated using the maximal number of half-sit-up that can be conducted in 1-min test.

Finally, after the rowers finish an incremental maximal test on the rowing ergometer Concept II model B, Morrisville, VT, USA, the aerobic fitness measurement shall be recorded. The test started with 5–10-min rowing session with "all-out" effort to ensure they achieved maximal levels of aerobic capacity. Heart rate was monitored using the Polar Heart Rate RS 100 Germany at the end of each moment and row until a steady state was obtained (5–10 min). Oxygen consumption will be measured using manual Eq. (1), to which we will connect the 2 points between submaximal heart rate (/min) and power (watt) due to record VO_2 max (L/min) level.

$$VO_{2\max} = \frac{x \times 1,000}{\text{Body weight}} = x\,\text{ml/kg/min} \tag{1}$$

3 Results

The demographic descriptive statistics for mean ± standard deviation (SD) of anthropometrics and fitness levels among the participants are presented in Table 1. Most of the athletes indicated normality of the data distribution on anthropometrics and fitness level. The present study indicated that elite rowers had higher values for most of the measurements, including height, length of the arm and leg, power, relative strength, muscular endurance, and also aerobic fitness.

The correlations between anthropometric characters and fitness level are presented in Table 2. The results showed that there were positive significant correlations ($p < 0.05$) between anthropometric variables (height, sitting height, arm span, arm length, forearm length, thigh length, leg length, and chest girth) with flexibility, power, relative strength, muscular endurance, and aerobic fitness.

4 Discussion

According to the present study, the findings showed that height, weight, and body length are the vital factors in rowing performance. It means the lighter a rower, the faster movement during rowing can be produced. In addition, identical findings were reported by several researchers [12, 21] where they discovered that body

Table 1 Anthropometrics and fitness level characteristics between rowers

Variables	Elite Mean ± SD	University Mean ± SD
Age	22.03 ± 1.06	21.07 ± 0.70
Height (cm)	177.12 ± 3.72	169.13 ± 3.19
Weight (kg)	71.67 ± 2.08	73.69 ± 2.86
Body fat (%)	6.13 ± 0.19	6.531 ± 0.26
Sitting height (cm)	132.47 ± 2.38	128.00 ± 3.48
Arm span (cm)	186.15 ± 3.98	180.39 ± 3.17
Arm length (cm)	31.86 ± 0.67	30.01 ± 0.88
Forearm length (cm)	25.37 ± 0.94	24.31 ± 0.79
Flexed arm girth (cm)	31.87 ± 0.99	31.33 ± 1.23
Femur breadth (cm)	9.22 ± 0.42	9.04 ± 0.43
Chest girth (cm)	94.88 ± 3.22	94.07 ± 2.86
Waist girth (cm)	74.28 ± 2.42	74.60 ± 3.20
Shoulder breadth (cm)	36.19 ± 1.85	34.73 ± 0.87
A-P chest depth (cm)	18.37 ± 1.64	16.40 ± 0.64
Humerus breadth (cm)	6.65 ± 0.37	6.72 ± 0.32
Thigh length(cm)	37.29 ± 2.03	32.99 ± 1.29
Leg length (cm)	48.18 ± 1.89	46.12 ± 1.19
Hip girth (cm)	92.96 ± 2.61	94.87 ± 3.98
Thigh girth (cm)	56.39 ± 1.56	55.63 ± 2.59
Calf girth (cm)	37.51 ± 0.94	34.80 ± 2.18
Flexibility (cm)	34.56 ± 3.55	30.73 ± 4.13
Power (cm)	47.67 ± 2.31	44.67 ± 2.52
Relative strength (kg)	5.06 ± 0.20	4.73 ± 0.18
Muscular endurance	76.60 ± 6.03	72.93 ± 2.84
Aerobic fitness (ml/kg/min)	51.91 ± 1.52	46.69 ± 1.58

weight was supported by a sliding seat in the boat; thus, they can afford to carry a greater mass and possess an advantage and it is believed rowing performance is significantly related to height [11]. Height and body length had a positive significant relationship for the entire fitness test variable. Higher rowers are able to make long rowing stroke length are thoroughly recognized with high-level rowing performance [18]. Upper limb and lower limb lengths are factors related to the stroke rate [7]. The length of feet improved upon the generate stage of the rowing stroke, during the catch and generate action including all arms and legs, leading to produce power stroke length [22]. The height and leg strength demonstrated the importance of leg and trunk length which could expand the driving phase. Though it is not a factor that can be trained, this could be handy to identify success in potential rowers.

Research on elite rowers have proven that size is not the only important factor, but also the ratio of height to arm span, such that proportionately longer arms provide a greater movement of stroke length. Thus, these factors might affect rowing performance, while the selection of competitive rowers might well focus upon these genetically determined aspects [7].

Table 2 Correlations between anthropometrics and fitness level among rowers

Anthropometric	Flx $n = 30$ (r)	Pwr $n = 30$ (r)	R.S $n = 30$ (r)	M.E = 30 (r)	A. F $n = 30$ (r)
Height	0.76**	0.74**	0.42*	0.45*	0.74**
Weight	0.29	0.18	0.43*	−0.12	−0.21
B. fat (%)	0.05	−0.21	−0.29	−0.26	−0.39*
Sitting height	0.60**	0.65**	0.29	0.45*	0.57**
Arm span	0.31**	0.58**	0.45*	0.48**	0.64**
Arm length	0.50*	0.68**	0.44*	0.30	0.73**
Forearm length	0.54*	0.22	0.32	0.37	0.45*
Thigh length	0.54*	0.57**	0.46**	0.43*	0.74**
Leg length	0.63**	0.26	0.29	0.38*	0.53**
Shoulder breadth	−0.03	0.32	0.24	0.43*	0.40*
A-P chest depth	0.16	0.48**	0.32	0.32	0.55**
Humerus breadth	0.16	0.07	−0.15	−0.06	−0.15
Femur breadth	0.10	0.34	0.28	0.09	0.25
Flexed arm girth	0.28	0.21	0.24	0.09	0.09
Chest girth	0.39*	0.48**	0.02	0.28	0.10
Waist girth	0.32	0.32	−0.17	0.04	−0.12
Hip girth	0.28	0.10	−0.32	−0.10	−0.32
Thigh girth	0.29	0.30	0.08	0.20	−0.04
Calf girth	0.22	0.55**	0.37*	0.39*	0.48**

*Correlation is significant at the 0.05 level (1 tailed)
**Correlation is significant at the 0.01 level (2 tailed)

Meanwhile, shoulder breadth had a positive significant relationship on muscular endurance and aerobic fitness. Meanwhile, chest girth had a positive significant relationship with flexibility and power. Calf girth had a positive significant relationship with power, relative strength, muscular endurance, and aerobic fitness. As the studies made by [22], informed rowing training for at least a year can improve some breadth and girth (arm and chest) among junior rowers. It was due to the years of training that affected the development of body structure which elite rowers were capable to develop large muscle mass (breadth and girth) which lead in increasing a higher muscle mass cross-sectional area, and therefore, a higher power and force output can be produced [24].

However, body fat percentage had negative significant relationship with aerobic fitness variables. In parallel with previous studies by [19], found that, body fat percentage was significantly negatively correlated with VO_2 max ($r = -0.534$, $p = 0.002$). An individual with a greater aerobic capacity most likely engages in enough physical activity to alter their body composition in a favorable manner. Engaging in exercise of a more anaerobic nature probably induces positive adaptations in a person's body composition. Therefore, having a low body fat percentage can be an advantage to succeed in rowing competitions [16]. Studies of male and female international rowers [10] have noted that the range of body fat percentage was from 6 to 10% and 11 to 15 % for male and female rowers, respectively.

Furthermore, the entire anthropometric variable (height, body length, and girth) had a positive significant relationship with flexibility. The elite rowers had a higher score in flexibility probably due to the contribution from body length (upper and lower limb). The reason for elite rowers to have a higher score of flexibility compared to university rowers was based on the years of training. Several exercises were included in the additional training which aimed at improving flexibility of the low back region and hamstrings [4].

The entire anthropometric variable (height, body length, breadth, and girth) had a positive significant relationship with power. Based on the result from the previous study made by Jurimae et al. [12], it indicates that strength and power assessment are highly predictive of traditional rowing performance.

Strength enhancement has an influence on speed and power besides providing the foundation for strength endurance [14]. In fact, the greater stage of maximal strength and muscular endurance and power in the elite rowers provide a benefit to maintain a more powerful stroke during the oar cycle [9, 12, 14]. Efficient elite rowers produce about 75–80 % of their power with their legs and 20–25 % with their arms during the rowing stroke [5].

Besides, relative strength had a positive significant relationship with height, weight, body length, and girth. Strength is the important criteria that must be developed among rowers. Strength is proportional to muscle size where this can be an indicator of a higher muscle mass cross-sectional area, and therefore, a higher power and force output may be produced during oar cycle and also stroke length [22]. But then, in rowing, the relative strength is most significantly variables that need to be implemented because it is closely related to the nature of rowing event.

The result was also supported by Mikulie and Ruzic [17], which claimed that relative strength is isometric vital to a rower than absolute strength due to the amount of body weight in a boat does affect the drag through water. An increase in absolute strength is of no benefit if the excess of bodyweight offsets the strength gain by increasing resistance through water when rowers increased the relative strength; on the other hand, they find it easier to speed up the boat because they have increased strength without increasing drag.

Muscular endurance had a positive significant relationship with height, body length, breadth, and girth. The result is quite similar to the previous study made by [3], which stated 1-min half-sit-up was used to measure the muscular endurance among elite Iranian Junior Rowers. Hence, it can be indicated that strength enhancement has an impact on speed and power. It also provides the basis for strength endurance. The truth is the greater levels of maximal strength, muscular endurance, and power in the elite rowers provide an advantage to maintain more highly effective stroke during the oar cycle.

Aerobic fitness had a positive significant relationship with height, body length, breadth, and girth among rowers. To gain a higher aerobic capacity, elite rowers are required to have the capability to maintain very high oxygen consumption, based on the fact that during a race, most oarsmen usually execute close to their maximum aerobic capacity for the entire length of the race [20].

Height and body length have a relationship with the aerobic fitness performance. It is because taller people have larger lungs. In this case, the vital capacity is typically increased in taller people especially by undergoing the incremental exercise [2]. Thus, establishing the exact levels of these parameters is required to succeed in this competition.

5 Conclusion

It can be concluded that anthropometrics (height, weight, and body length) and fitness level (power, relative strength, muscular endurance, and aerobic fitness) have a strong relationship toward rowers' performance. The results of the present study provides new profiling data on anthropometric and fitness levels of Malaysian rowers that can be used by sport scientists, coaches, and athletes. The data are useful for constructing anthropometric profiles for individual rowers to improve individual training programs in the future. The anthropometric and fitness profiles of elite and university male rowers can contribute toward skills selection and recognition and could also be of importance for maximal development of strength, power, and endurance training programs for talent identification.

References

1. Ackland, T., Kerr, D., Hume, P., Norton, K., Ridge, B., Clark, S. & Ross, W. (2001). Anthropometric normative data for Olympic rowers and paddlers. In *Australian conference of science and medicine in sport*. Perth: Sports Medicine Australia:157.
2. Adams, G. M., & Beam, W. C. (2007). *Exercise physiology: Laboratory manual* (5th ed.). New York: McGraw-Hill.
3. Arazi, H., Faraji, H., & Mohammadi, S. M. (2011). Anthropometric and physiological profiles of elite Iranian junior rowers. *Middle-East Journal of Scientific Research, 9*(2), 162–166.
4. Bourgois, J., Claessens, A. L., Vrijens, J., Philippaerts, R., Renterghem, B. V., Thomis, M., et al. (2000). Anthropometric characteristic of Elite male junior rowers. *Journal Sports Medicine, 34*, 213–217.
5. Cosgrove, M. J., Wilson, J., Watt, D., & Grant, S. F. (1999). The relationship between selected physiological variables of rowers and rowing performance as determined by a 2000 m ergometer test. *Journal of Sports Sciences, 17*(11), 845–852.
6. De Garay, A. L., Levine, L., & Carter, J. E. L. (1974). Genetic and anthropological studies of Olympic athletes. Waltham: Academic Press.
7. Dimakopoulou, E., Blazevich, A. J., Kaloupsis Diafas, S. V., & Bachev, V. (2007). Prediction of stroking characteristics of elite rowers from anthropometrics variables. *Journal of Sports Science, 1*(3), 89–96.

8. Grant, S. F. (1999). The relationship between selected physiological variable of rowers and rowing performance as determined by a 20,000 m ergometer test. *Journal of Sports Sciences, 17*(11), 845–852.
9. Gabarren, M. I., Exposito, G. D. T., & Izquierdo, M. (2010). Physiological factors to predict on traditional rowing performance. *Journal of Applied Physiology, 10*, 83–92.
10. Hagerman, F., & Toma, K. (1997). Physiological evolution of the rowing Athlete: A 25-year Study.
11. Ingham, S., Whyte, G., Jones, K., & Nevill, A. (2002). Determinants of 2,000 m rowing ergometer performance in elite rowers. *Journal of Applied Physiology, 88*(3), 243–246.
12. Jurimae, T., Turpin, J. A. P., Tormo, J. M. C., Mira, I. J. C., Anta, R. C., Maestu, J., et al. (2010). Relationship between rowing ergometer performance and physiological responses to upper and lower body exercises in rowers. *Journal of Science and Sport Medicine, 13*(4), 434–437.
13. Kaloupsis, S., Bogdanis, G. C., Dimakopoulou, E., & Maridaki, M. (2008). Anthropometric characteristics and somatotype of young Greek rowers. *Journal of Biology Sports, 25*(1), 57–69.
14. Maestu, J., Jurimae, J., & Jurimae, T. (2005). Monitoring of performance and training in rowing. *Journal of Sport Medicine, 35*(7), 597–617.
15 Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *Journal Strength and Conditioning, 18*(3), 551–555.
16. McLester, J. R., Green, J. M., Wickwire, P. J., & Crews, T. R. (2008). *Relationship of VO2 peak, body fat percentage, and power output measured during bouts of a wingate protocol*. DigitalCommons@ Kennesaw State University.
17. Mikulie, P., & Ruzic, L. (2008). Predicting the 1,000 m rowing ergometer performance in 12 and 13 year old rowers: The basis for selection process. *Journal of Science and Medicine in Sport, 11*(2), 218–226.
18. Muller, G., Hille, E., & Szpalski, M. (1994). Function of the trunk musculature in elite rowers. *Sportverletzung Sportschaden, 8*(3), 134–142.
19. Nolte, V. (2011). How to build rowing strength. 2nd edition. *Human Kinetics* (2nd ed.). Retrieved from http://www.humankinetics.com/all-outdoor-activities-articles/all-outdoor-activities-articles/how-to-build-rowing-strength.
20. Secher, N. H., & Vaage, O. (1990). Rowing performance, a mathematical model based on analysis of body dimensions as exemplified by body weight. *Journal of Applied Physiology, 52*, 88–93.
21. Secher, N. H., Vaage, O., & Jackson, R. C. (1983). Rowing performance and maximal aerobic power of oarsmen. *Journal of Sport Science, 4*, 9–11.
22. Singh, R., Singh, H. J., & Sirisinghe, R. G. (1995). Physical and physiological profile of Malaysian dragon boat rowers. *Journal of Sport Medicine, 29*(1), 13–15.
23. Slater, G. J., Rice, A. J., Mujika, I., Hahn, A. G., Sharpe, K., & Jenkins, D. G. (2005). Physique traits of lightweight rowers and their relationship to competitive success. *Journal of Sport Medicine, 39*, 736–741.
24. Piotrowski, J., Sklad, M., Krawczyk, B., & Majle, B. (1992). Somatic indices of junior rowers as related to their athletic experience. *Journal of Biology of Sport, 9*, 117–124.