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A Comparative Study of Selected Anthropometric and Physiological Variables Among Indian National Paddlers

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Resumen

Introducción: Canotaje y Kayak son deportes acuáticos caracterizados por la habilidad y la resistencia. Las variables fisiológicas y antropométricas juegan un papel sustancial en casi todos los juegos y deportes, y el piragüismo y el kayak no podrían separarse de ellos. Se han llevado a cabo varias investigaciones en el campo del piragüismo y el kayak, incluidas las características antropométricas y fisiológicas, pero muy pocos estudios de estos estudios se concentraron en los remeros indios. Por lo tanto, nuestro estudio tuvo como objetivo evaluar los perfiles antropométricos y fisiológicos de los canoeros y kayakistas indios masculinos y femeninos y determinar y explicar las diferencias entre estos grupos. **Método:** Los parámetros antropométricos se midieron de acuerdo con los protocolos estándar seguidos por el manual ISAK. La densidad corporal se predijo utilizando la ecuación de Durnin y Womersley (1974) y el porcentaje de grasa corporal utilizando el método de Siri (1956). El VO2max se predijo a partir de la prueba de condición física de etapas múltiples (MSRT). **Resultados:** Se encontró que la masa corporal magra era mayor en kayakistas que en canoeros. Se encontró que el porcentaje de grasa corporal era significativamente más alto entre las kayakistas que entre las canoeras, que fue de 26,53±4,28 y 18,96±1,54 respectivamente. Las variables fisiológicas en cuestión mostraron que la fuerza relativa de la espalda y el consumo de oxígeno de las canoistas femeninas fueron significativamente más altos que los de las kayakistas, que fueron 2,22 ± 0,14 kg, 45,20 ± 2,17 ml/min/kg y 1,83 ± 0,18 kg, 40,71 ± 2,87 ml/min. /kg respectivamente. **Conclusión:** Se encontró que tanto los kayakistas masculinos como femeninos eran más altos y pesados que los canoeros masculinos y femeninos, respectivamente.

Palabras Clave: Características antropométricas, Perfil fisiológico, Kayak, Canotaje.

Abstract

Introduction: Canoeing and Kayaking are water sports featured by skill and endurance. Physiological and anthropometric variables play a substantial role in almost all games and sports and Canoeing and Kayaking could not be segregated from them. Several researches had been carried out in the field of Canoeing and Kayaking including anthropometric and physiological characteristics but very scanty account of these studies was concentrated on Indian paddlers. Hence, our study aimed at assessing the anthropometric and physiological profiles of Indian male and female Canoers and Kayakers and determining and explaining the differences between these groups. **Method:** Anthropometric parameters were measured according to standard protocols followed by ISAK manual. Body density was predicted using Durnin and Womersley equation (1974) and body fat % using the Siri method (1956). VO_{2max} was predicted from Multi-Stage Fitness Test (MSRT). **Results:** Lean body mass was found to be higher in Kayakers than Canoers. Body fat percentage was found to be significantly higher among female Kayakers than female Canoers which was 26.53±4.28 and 18.96±1.54 respectively. Physiological variables when concerned showed that relative back strength and oxygen consumption of female Canoers were significantly higher than that of female Kayakers which were 2.22±0.14 kg, 45.20±2.17ml/min/kg and 1.83±0.18kg, 40.71±2.87ml/min/kg respectively. **Conclusion:** It had been found that both male and female Kayakers were found to be taller and heavier than the male and female Canoers respectively**.**

Keywords: Anthropometric characteristics, Physiological profile, Kayaking, Canoeing.

Introduction

Paddle sports had been of great interest for researchers since long. Canoeing and kayaking occupy a special place in water sports due to their passive recreation, hiking, boating, inexpensive, ease of care for the equipment, etc. Both of these sports are based on skill, endurance, strength and power that enables a paddler to stay on the boat and pull it towards the finishing point. Sprint canoeing is a cyclic sport which includes two disciplines - kayaking and canoeing, both aiming to cover a particular distance as fast as possible and crossing the end line earlier than the opponents. Within a specific sport, there are numerous disciplines or playing positions with particular needs that require different approaches in training and are related to different physical and morphological traits (Secher 2000). Kayaking motion mainly consists of double-blade paddle cyclic movements in both sides of the boat, coordinated via pedaling movements and trunk rotation in seated position, and while canoeing includes single-blade paddle cyclic moves carried out at the same side of the boat from a kneeling position. Flatwater kayaking and canoeing is a sport that require exceptional demands on upper-body muscle strength, anaerobic capacity and endurance in addition to high aerobic power. Canoeing and kayaking are "upper body sports", demanding specific morphological-functional characteristics on this part of the athletes (Mann and Kearney 1980). Elite flat-water kayak paddlers were characterized with reference to body composition, muscle strength and endurance for upper-body exercise (Tesch 1983). Though, extensive anthropometrical and physiological studies have been carried out on the rowers, very limited information was available on kayakers and canoers.

Anthropometry and physiology play an important role in deciding the particular build of the body with various measurements of the segments of the body. Anthropometry plays an important role in deciding the particular built of the body with various measurements of the body segments, suitable for a particular game and sports and essentially helpful to excel in that game. Although the anthropometric characteristics of kayakers have been extensively described (Wang et al. 2005), there is limited research comparing different flatwater competitive categories. Traditionally, kayak research has focused on determining the anthropometric characteristics and physiological level of international kayakers in an attempt to identify the determinants of optimal performance (Ackland et al. 2003, Tesch et al. 1983, van Someren and Howatson 2003). Most successful paddlers have shown larger anthropometric parameters resulting in a more robust and compact morphology (Fry and Morton 1991, van Someren and Palmer 2003). Considering the novelty of this sport and the limited scientific literature, the main objective of this study was to determine some basic physiological characteristics among National Kayakers and Canoers in Odisha.

Material and Methods

Participants

A cross sectional study was conducted on total 29 Indian National Paddlers to assess the differences in anthropometry and physiological variables; out of which, 10 male kayakers (n=10, age=17.9±2.03years), 7 female kayakers (n=7 age=19.3±1.25 years) and 7 male canoers (n=7, age= 16.7±2.14 years), 5 female canoers (n=5, age=18.8±1.92 years) participated in this study. All the athletes belonged to the National Centre of Excellence of Sports Authority of India (SAI), Jagatpur, Odisha. All of them obtain similar nutritional habits and training at same geographical and climatic conditions. All the subjects were informed of the purposes, procedure, risk and benefits of the tests prior taking the assessments and written consent was obtained.

Procedures

The anthropometric variables viz. body weight, body height and arm span were measured initially. In addition, five skinfolds (triceps, biceps, subscapular, supra-illiac and medial calf) were taken and using the skinfold data, the percent body fat, fat mass and lean body mass were calculated (Durnin & Womersley, 1974). Equipments used were Harpenden skin-fold caliper (to the nearest 0.01 mm) to obtain skinfolds; anthropometer (GPM, Swiss) for measuring height (cm) to the nearest 0.1 cm and electronic weighing scale to measure body weight to the nearest 0.1 kg. Various field-based tests were used for the assessment of physiological parameters. Running based anaerobic sprint test (RAST) was used to determine the anaerobic capacity. The test was commenced by measurement of the athletes' body weight. This test consisted of 6 sprints of 35-meter of running track with a minimum 10 second for recovery period (MacKenzie, 2005). Maximum oxygen consumption (VO_2 max) was estimated by using Multi-Stage Fitness Test (MSRT) or Beep Test. Subjects were involved to running 20 meter shuttles in time with an audible beep until reaching the volitional exhaustion. Running speed start with 8.5 km/h and sound indicated an increase in speed of 0.5km/h per minute (Kavcic et al., 2012). Standing broad Jump test (SBJ) and Overhead medicine ball throw test (OMBT) were employed for the determination of explosive power of lower and upper body muscles. Hand grip strength and back strength were assessed by using digital back strength and

hand grip dynamometer following a standard procedure (Johnson and Nelson, 1988). Extension of hamstring muscle as well as the flexion of hip and back muscle was determined by Sit and Reach Test following a standard procedure (Baudouin and Hawkins, 2004).

Statistical Analysis

To assess the differences between two groups according to their sports discipline, Student t- test was used. All data was presented as means ± standard deviation (SD). Pearson's correlation coefficient was used to determine the relationships between physical characteristics and different physiological variables. The Statistical Program for the Social Sciences (SPSS) version 25.0 for Windows (SPSS Inc., Chicago, II, USA) was used for data analysis. The value of $p< 0.05$ was considered to be statistically significant.

Results

Table 1. Comparison of Physical and Anthropometric Parameters Between Male Kayakers and Canoers

Variables	Male	
	Kayaking (n=10)	Canoeing (n=7)
Age (years)	17.9±2.03	16.7±2.14
Height (cm)	173.2±7.32	173.0±3.89
Body weight (kg)	69.1±6.47	65.6±2.82
BMI (kg/m^2)	23.0±1.73	22.0±1.17
Body fat %	12.3±3.16	12.1±3.32
Fat mass (kg)	8.6±2.82	8.0±2.20
Lean Body mass (kg)	60.5±4.70	57.6±3.21
Arm Span (cm)	177.7±12.88	175.4±4.83
Calf-circumference (cm)	35.5±1.52	36.9±1.06*

Values are expressed as mean ± SD. $p<0.05$ was considered to be statistically significant. * = $p<0.05$; #= $p<0.01$; $ = $p<0.001$.

Table 2. Comparison of skin fold measurements of male Kayakers and Canoers

Variables	Male	
	Kayaking (n=10)	Canoeing (n=7)
Biceps (mm)	4.1±1.29	3.9±0.30
Triceps (mm)	7.4±2.68	6.6±1.16
Subscapular (mm)	10.4±3.13	9.3±1.71
Suprailiac (mm)	6.7±2.78	5.9±1.77
Calf (mm)	7.2±2.62	5.9±0.93
Sum of skinfold (mm)	35.8±11.84	36.1±4.42
Values are expressed as mean ± SD. $p<0.05$ was considered to be statistically significant. * = $p<0.05$; #= $p<0.01$; $ = $p<0.001$.		

Physical and anthropometric parameters of Indian male paddlers on the basis of sports discipline are depicted in Table 1. Calf circumference of male canoeist was found to be significantly higher than that of kayakers (p=0.042).

There is no significant difference between biceps, triceps, subscapular and supra-iliac skinfolds of male kayakers and canoers (Table 2).

Table 3. Comparison of physiological parameters of male Kayakers and Canoeists

Variables	Male	
	Kayaking (n=10)	Canoeing (n=7)
VO2 max (ml/kg/min)	51.7±7.2	53.9±4.81
Maximum Anaerobic Power (Watts)	457.2±76.8	445.4±59.5
Fatigue Index (Watts/Sec)	2.06±0.04	2.02±1.22
Right handgrip strength (Kg)	50.7±4.89	47.9±4.57
Left handgrip strength (Kg)	49.9±4.67	45.4±5.15
Relative Back Strength	2.16±0.38	2.3±0.32
Standing broad Jump (cm)	245.1±17.56	236±13.03
Medicine Ball Throw (cm)	586.3±56.0	575.4±52.7
Flexibility (cm)	20.4±6.79	20.7±3.82

Values are expressed as mean ± SD. $p<0.05$ was considered to be statistically significant. * = $p<0.05$; #= $p<0.01$; $ = $p<0.001$.

Table 4. Pearson's correlation coefficient of different physical parameters with physiological parameters of male Kayakers and Canoers

Parameters	VO2 max	AnP Max	FI	RBS
Age	-0.091	-0.281	-0.236	0.228
Height	0.296	0.005	-0.040	-0.694*
Weight	0.054	0.116	0.053	-0.525#
BMI	-0.207	0.152	0.122	0.074
Body fat%	-0.224	0.378	0.351	-0.450
Arm Span	0.231	0.011	-0.071	-0.570*
Calf circumference	-0.405	0.324	0.375	-0.120
Sum of skin fold	-0.559*	-0.065	-0.066	-0.113

n=17; BMI: body mass index; VO2max: max aerobic capacity; AnP Max: anaerobic power maximum; FI: fatigue index; RBS: Relative back strength.

Significance levels have been indicated as superscripts next to the values. * = $p<0.05$; #= $p<0.01$; $ = $p<0.001$.

Comparison of physiological parameters between male kayakers and canoers is presented in Table 3 and no significant difference was found between kayakers and canoers.

Table 4 represents correlation coefficients of different physical parameters with physiological parameters of male canoe sprint players. It has been found from the result that height and weight were negatively correlated with the relative back strength (r = -0.694 and r = -0.525) and arm span was negatively correlated with relative back strength (r = -0.570). Sum of skin fold was negatively correlated with maximum aerobic capacity at (r = -0.559).

Comparison of physical and anthropometrical parameters of female kayak and canoe athletes is represented in Table 5. Body fat percentage and fat mass of kayakers was significantly higher than canoers at (p =0.048) and (p =0.039) respectively.

Table 5. Comparison of physical and anthropometrical parameters of female Kayakers and Canoers

Variables	Female	
	Kayaking (n=7)	Canoeing (n=5)
Age (years)	19.3±1.25	18.8±1.92
Height (cm)	160.9±6.45	158.9±2.80
Body weight (kg)	56.7±5.99	53.0±1.71
BMI (kg/m^2)	22.0±3.19	21.0±0.91
Body fat %	26.5±4.28	18.96±1.54*
Fat mass (kg)	15.4±4.03	11.2±1.70*
Lean Body mass (kg)	41.5±2.57	41.2±1.40
Arm Span (cm)	164.0±5.27	161.7±2.60
Calf-circumference (cm)	33.7±2.25	31.9±0.78

Values are expressed as mean ± SD. p<0.05 was considered to be statistically significant. * = p<0.05; #= p<0.01; $ = p<0.001.

Table 6. Comparison of skin folds measurements of female Kayakers and Canoeists

Variables	Female	
	Kayaking (n=7)	Canoeing (n=5)
Biceps (mm)	8.1±3.74	5.2±1.24
Triceps (mm)	15.1±5.96	10.2±4.46
Subscapular (mm)	11.1±3.43	10.3±3.10
Suprailiac (mm)	13.0±4.99	9.0±2.67
Calf (mm)	14.6±6.47	9.6±3.54
Sum of skinfold (mm)	61.9±22.74	44.3±14.46

Values are expressed as mean ± SD. p<0.05 was considered to be statistically significant. * = p<0.05; #= p<0.01; $ = p<0.001.

Table 7. Comparison of physiological parameters of female kayakers and canoeist

Variables	Male	
	Kayaking (n=7)	Canoeing (n=5)
VO2 max (ml/kg/min)	40.7±2.87	45.2±2.17*
Maximum Anaerobic Power (Watts)	196.1±50.20	186.8±21.56
Fatigue Index (Watts/Sec)	1.8±0.86	1.5±0.51
Right handgrip strength (Kg)	33.8±2.51	32.2±1.54
Left handgrip strength (Kg)	32.3±2.60	30.9±2.24
Relative Back Strength	1.83±0.18	2.2±0.14#
Standing broad Jump (cm)	182.0±13.0	190.0±3.74
Medicine Ball Throw (cm)	423.1±53.50	387.0±29.70
Flexibility (cm)	17.7±6.24	18.2±4.49

Values are expressed as mean ± SD. p<0.05 was considered to be statistically significant. * = p<0.05; #= p<0.01; $ = p<0.001.

Table 6 represents comparison of skin fold parameters between female kayakers and canoers. Although, no significant difference was found between kayakers and canoers.

Table 7 represents the comparison of physiological parameters between female kayakers and canoer, where VO2 max and relative back strength of canoer group was found to be significantly higher than their kayakers' peers at (p =0.013), (p= 0.002) respectively.

Correlation coefficients of different physical parameters with physiological parameters of female canoe sprint players are represented in Table 8. Body weight and BMI were positively correlated with anaerobic power and fatigue index at (r =0.692, r = 0.666 and r =0.807, r = 0.748) respectively. Body fat% was negatively correlated with maximum aerobic capacity and relative back strength (r =-0.637, r = -0.803). Calf circumference was positively correlated with maximum anaerobic power (r =0.661) and fatigue index (r = 0.679).

Table 8. Pearson's correlation coefficient of different physical parameters with physiological Parameters of female kayakers and canoeist

Parameters	VO2 max	AnP Max	FI	RBS
Age	-0.277	-0.055	0.073	-0.212
Height	-0.419	-0.457	-0.386	-0.229
Weight	-0.627*	0.692*	0.666*	-0.768#
BMI	-0.283	0.807#	0.748#	-0.501
Body fat%	-0.637*	0.486	0.423	-0.803#
Arm Span	-0.254	-0.568*	-0.458	-0.248
Calf circumference	-0.451	0.661*	0.679*	-0.686*
Sum of skin fold	-0.637*	0.538	0.466	-0.724#

n=12; BMI: body mass index; VO2max: max aerobic power; AnP Max: anaerobic power maximum; FI: fatigue index; RBS: Relative back strength.

Significance levels have been indicated as superscripts next to the values. * = p<0.05; #= p<0.01; $ = p<0.001.

Discussion

A number of underlying anthropometric, physical and physiological factors may contribute to an elite athlete's performance capacity. Since the pattern of movement in canoe sprint differs apparently between canoe and kayak, the physical characteristics and fitness may also vary between the competitions (Hamano et al. 2015). However, very limited information regarding kayak and canoe is available. In our study, we have critically analyzed the physical, anthropometric and physiological characteristics of Indian national kayak and canoe players with a view to find any comparison between these two groups. The result of this study showed that there is no significance difference has been found between height, body weight, BMI, body fat percentage, lean body mass, fat mass of male kayak and canoe athletes. Calf circumference of canoers was found to be significantly higher than kayakers (*p*=0.042) which is in line with the study (Manna and Adhikari 2018). No significance difference has been found in terms of body weight of kayakers and canoers and these findings are also in line with the study (Manna and Adhikari 2018). Body weight of sprint paddlers was significantly higher than kayakers (78.1±4.9kg, 75.5±8.0kg) (Hagner-Derengowska et al. 2014). Body fat % (26.5±4.28) of female kayakers was found to be significantly higher than that of female canoers (21.6±3.22). These findings were consistent with results of several studies one of the important works of which is done by research study showed that body fat % of kayakers was slightly higher that has been documented (Akca and Muniroglu 2008). It was observed that no significance difference has been found in biceps, triceps, subscapular, suprailiac, calf and sum of skinfolds of kayakers and canoers. It was further observed that VO2max, i.e. the aerobic capacity of female canoeist was found to be significantly higher than kayakers.VO2 max of kayakers was found to be slightly lower than that has been found in another recent study and that of canoers of our present study was slightly higher than that has been found in this study (Hamano et al. 2015). In case of standing broad jump, medicine ball throws no significant difference has been found among kayakers and canoers. Significant difference was observed in relative back strength of female canoeist than kayakers.

Table 4 shows that height and body weight of male athletes has a negative significant correlation with relative back strength at (r = -0.694 and r = -0.525), arm span of male athletes has a significant negative correlation with relative back strength at (r = -0.570) and these contradicts previous studies in which the BMI and lean body mass, along with other basic anthropometric variables and body mass have been found to be positively related to better performance in kayaking and canoeing (van Someren and Oliver 2001; Fry and Morton 1991).

Conclusion

This is the first study carried out to compare the selected anthropometric and physiological parameters of Indian paddlers. The primary finding of this study indicates that body fat percentage of female kayakers was higher than canoers. VO_2 max and relative back strength were comparatively higher in female canoers than female kayakers. Our findings suggest that factors associated with performance differ according to the discipline. As a result, it is important to implement a different training program based on the type of event. It will be useful to consider the findings of this study when planning training programs and in identifying talented athletes. Future researches shall be focused on the comparison of anthropometric and physiological parameters of larger sample size of Indian paddlers before and during the competitive season that may enable to understand the systematic training effect based on their specific roles in the game. The aforementioned findings shall help the coaches, sports scientists, and paddlers with detailed insight into the anthropometry and physiology in Indian context.

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