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A comparative study of anthropometric and physical profiles of male junior rowers, kayakers and canoers

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Abstract. Rowing, canoeing and kayaking are the very popular water-sports which involve both skill and power. Several investigators stresses on the anthropometric and physical characteristics of the players for achieving success at the international level. However, in this regard, there is a paucity of knowledge for making any comparison of these three closely related sports. *Aim.* The objective of the present study is to evaluate various physical and anthropometrical parameters of Indian junior male rowers, kayakers and canoers and also to explore the differences among them. *Material and Method.* The present study was conducted on 17 male rowers (n = 17, age = 16.2 ±1.51 years), 15 male kayakers (n = 15, age = 17.0 ±3.99 years) and 9 male kayakers (n=9, age = 15.1±0.53) respectively. Various physical and body anthropometrical parameters were measured using standard methods. *Results.* The height of male kayakers was found to be significantly higher than that of canoeists (p= 0.035). The arm span of rowers was found to be significantly higher than that of kayakers (p=0.007). The ectomorphic element and forearm length of rowers were found to be significantly higher than canoers (p=0.003) and (p=0.001).The trunk flexibility of rowers was found to be significantly higher than canoeists (p=0.014). *Conclusions*. The findings of the current study can be useful in talent identification and new induction while planning the training programs.
Key words*: rowers, kayakers, canoeist, anthropometry, physical profile.*

Introduction

A water sport recreates any one more entreating than any other sporting events. There are a large number of sports that involve water. Most of these are very popular involving motor skills and power. Rowing, canoeing and kayaking are not exempted from those excellences (1, 2). Rowing ranks at the topmost of the list as because of higher physiological demand of any aerobic sport. The body's ability to uptake, carry, deliver, and use of oxygen is one of the best measures of aerobic fitness. Strength testing and training appears relatively ingrained as part of the physical preparation plans of rowers (3). Rowing involves nearly about 70% of the skeletal muscle tissue in the rower's body during a single stroke cycle (4). Good anaerobic and aerobic capacity, strength, power and agility are the most important determinants to achieve success in rowing competitions (5, 6). Anthropometric data of adult male and female rowers may be very much helpful not only during the initial talent hunt, but also for the wedding out and retention of the non-responders to the training. It also emphasizes the importance of body mass and physique in determining successful rowing performance at an international level.

Though, extensive physiological studies have been done on the rowers, very limited information was available on kayakers and canoers. Kayak is a sleek boat, close to the surface of water, and its smooth design enables it to move faster, and the wind cannot affect its speed. Within particular sports, there are various disciplines or playing positions with specific demands that require different approaches in training and are associated with different physical and morphological characteristics (7).

Sprint canoeing is a cyclic sport which consists of two disciplines - kayaking and canoeing; both aiming to cover a specific distance as quickly as possible, and crossing the finish line before the opponents. Also biomechanical perspective, during kayaking movement mainly consists of double-blade paddle cyclic movements in both sides of the boat, coordinated through pedalling movements and trunk rotation in seated position, and whereas canoeing consists of single-blade paddle cyclic movements performed on the same side of the boat from a kneeling position. For the success of the canoeist, maximal aerobic power is more

critical than body weight, because the slightly greater resistance caused by the friction of the canoe in the water by a few kilograms of extra body weight.
One of the latest research (8) have evaluated selective physical, physiological and motor ability profiles of Indian female rowers to enumerate the effects of systematic training on these parameters correlating them with their rowing performances. In spite of extensive physiological studies carried out on rowers, very limited information is available on kayakers and canoes. So, it is of great interest for the present study to explore some basic physiological and motor skill ability differences among these water-sports of young male in Indian continent.
The main objective of the present study was to evaluate if there is any differences between the anthropometrical and physical parameters among the male junior rowers, kayakers and canoers.

Material and method
Participants. The present study was conducted on 17 male rowers (n = 17, age = 16.2 ±1.51 years) and 15 male kayakers (n = 15, age = 17.0 ±3.99 years), and 9 male kayakers (n=9, age15.1±0.53) respectively. The entire oarsman belonged to the Special area Game scheme of Sports Authority of India (SAI), Jagatpur, Orissa. The oarsman was at least of the state level performer with a minimum of 4–5 years of formal training history. They had almost the same socio-economic status with similar dietary habits and of similar training at same geographical and climatic conditions. Hence, these subjects were considered as homogenous.
Prior to initial testing, a complete explanation of the purposes, procedures, potential risks and benefits of the tests were given to the athletes. Clinical examinations of the participants were also performed by SAI physicians who were specialized in Sports Medicine.
Training regimen. The subjects of the present study were having at least 4-5 years of prior formal training. The formulation and implementation of training program was made by the qualified coaches/trainers of SAI. The training regimen was applied 24 to 30 hours a week (six days/week). The training schedule comprised of different training on the land (ergometer for rowers only) and training on boats along with their specific skill training in respective events. The land training schedule included different strength, speed, and endurance training programs along with flexibility exercises. Strength and endurance training was also applied according to their event specific requirement. The training schedule also consisted of prior warming up and post cooling down session. The training protocol was made keeping the scheduled competitions throughout the season under consideration. Besides the technical and tactical training, the players were also provided with psychological or mental training session. In rowing the two oars descend more deeply in water creating more resistance than paddling. As rowers face the rear of the boat, legs are also used to press against foot stops to propel the upper body into the oar stroke. Special training is given to the rowers for the improvement of their upper body strength. In kayaking paddler faces forward, but legs also play a large role in a proper kayak paddling stroke. Canoeing requires a combination of strength, power, speed, endurance and balance.
Procedures. The physical characteristics of the groups including height (cm) and weight (kg) were measured by an anthropometric rod and digital scales, respectively, following a standard procedure (9). The decimal age of all the subjects was calculated from their date of birth recorded from the original birth certificate, produced by them at the time of testing. The Body Mass Index (BMI) was calculated from body height and weight (10). All anthropometrical measurements including arm span, upper arm length, fore arm length, fore leg length, thigh length, trunk length were measured with the help of anthropometrical measuring tape. Diameter of humorous and femur were measured with sliding calliper with Vernier scale (GPM, Swiss). Skin fold measurements from five sites i.e., biceps, triceps, sub scapular, supra-illiac and calf were taken with the help of manual skin fold calliper.
To the estimation of the anaerobic capacity, the running based anaerobic sprint test (RAST) was used. The test was preceded by measurement of the competitors' body weight. Competitors performed a standard 10-15 minute athletic warm up, after which a 5 minute pause followed before the test. The test consisted of 6 runs with maximum speed on the distance of 35 meters, with a minimum 10-second pause among them; just for turning back (11).
Multi-stage Fitness Test (MSRT) or Bleep Test involved continuous running between two lines of 20 meters apart in time to recorded beeps freely downloaded from *https://www.topendsports.com.* The test subject stops on a marked line, turns by 180º and runs in the opposite direction. One must stop when instructed by the beep sound. The speed at the start is 8.5 km/h and after about a minute a sound indicates an

increase in speed (0.5 km/h per minute). The test was stopped when the subjects were unable to keep up with the pace dictated by the beep sound (12).

Sit ups per minute and push up per minute were considered by counting the number of complete sit ups and push ups an oarsman can perform within the given time. Back strength and hand grip strength (using right and left hand) were measured by a back and grip dynamometer (Senoh, Japan) following a standard procedure adopted from Johnson and Nelson (13). The hip and back flexion as well as extension of the hamstring muscles was evaluated by a modified Sit-and Reach Test using a flexometer (Lafayette Instrumental Co., USA) following a standard procedure (8).

Haemoglobin content (g/dL) was detected with the help of an automatic (Mission Digital) Haemoglobin Testing Meter. Ethical matter and aseptic measures were greatly considered before testing.

Statically analysis. Data were analysed using the Statistical Program for the Social Sciences (SPSS) version 23.0 for Windows (SPSS Inc., Chicago, Il, USA). Differences between groups for all variables according to their sports category were calculated using a one-way analysis of variance (ANOVA) and a matrix of correlation coefficient. All values were expressed as means ± standard deviation (SD). A confidence level at $p < 0.05$ was considered as significant.

Results

Table 1, represents that the height of male kayakers was found to be significantly higher than that of canoeists (*p*=0.035), arm span was significantly higher in case of male rowers than kayaker (*p*=0.007) and rowers have significantly higher ectomorph element (*p*=0.003) than canoeists. Haemoglobin content of rowers was found to be significantly higher (*p*=0.021). Table 2, represents that forearm length of male rowers was found to be significantly higher than that of canoeists (*p* =0.001).

Table 1. Comparison of some physical and anthropometrical parameters of male rowers, kayakers and canoeist

Variables	Male			F value (level of significance)	*P* value	Post Hoc
	Rowing (n=17)	Kayaking (n=15)	Canoeing (n=6)			
Age (years)	16.2±1.51	17.0±3.99	15.1±0.53	1.319	0.287	-
Height (cm)	173.1±3.74	176.1±7.97	169.7±2.51	3.907	0.035	K*Vs .C
Body weight(kg)	63.3±5.32	64.4±8.61	63.0±4.42	0.217	0.806	-
BMI (kg/m$^{2)}$	21.2±1.36	20.8±2.67	21.9±1.37	0.855	0.439	-
Body fat%	14.4±3.43	14.86±3.76	15.34±1.78	0.212	0.811	-
Arm Span(cm)	183.9±5.15	176.2±4.17	171.2±28.25	6.281	0.007	R*Vs.C
Endomorph	2.8±0.58	2.8±0.87	3.75±0.55	6.414	0.006	C*Vs.R
Mesomorph	0.9±2.02	4.2±0.97	5.15±0.44	6.259	0.007	C*Vs.R
Ectomorph	3.6±0.46	3.6±0.65	2.6±0.73	7.285	0.004	R*Vs.C
Haemoglobin (g/dL)	14.9±0.99	13.8±1.05	14.3±0.91	2.113	0.021	R*Vs .K

Table 2. Comparison of some anthropometrical parameters of male rowers, kayakers and canoers

Variables	Male			F value (level of significance)	*P* value	Post Hoc
	Rowing (n = 17)	Kayaking (n =15)	Canoeing (n =9)			
Foreleg length (cm)	44.8±5.57	42.5±3.62	40.1±2.23	2.756	0.085	-
Thigh length (cm)	49.2±6.28	53.9±5.03	50.9±4.99	1.594	0.225	-
Foot length (cm)	25.8±1.47	26.1±1.73	24.6±0.92	2.509	0.103	-
Upperarm length (cm)	25.8±1.47	32.7±2.60	31.2±1.83	1.484	0.248	-
Forearm length (cm)	34±2.07	31.6±0.84	30.2±2.25	10.002	0.001	R*Vs.C
Shoulder breadth (cm)	50.3±3.13	48.6±1.68	48.4±2.77	1.434	0.259	-
Trunk length (cm)	51.8±1.87	54.2±3.37	52.1±2.29	2.324	0.259	-
Calf-circumference (cm)	34.0±2.39	34.1±2.57	37.81±1.51	8.027	0.002	C*Vs.R
Thigh circumference (cm)	45.6±1.81	45.2±3.19	47.4±2.58	1.735	0.199	-
Mid Upper Arm Circumference (MUAC) (cm)	27.5±1.60	27.7±2.64	33.5±1.49	28.792	0.000	C*Vs.R
Humerus (cm)	5.7±0.77	5.3±0.18	6.0±0.37	3.259	0.057	-
Femur (cm)	8.8±0.69	8.7±0. 69	8.6±0.44	1.712	0.203	-

Table 3 represents that there are no significant difference between biceps, triceps, subscapular and supra-iliac skinfolds of rowers, kayakers and canoers. Table 4, represents that the aerobic power of rowers was found to be significantly higher than canoeists (*p*=0.045). Fatigue index and flexibility were found to significantly higher in case rowers than canoers (*p*=0.014).

Table 3. Comparison of skin folds measurements of male rowers, kayakers and canoers

Variables	Males (14-18 years)			F value (level of significance)	p value	POST HOC
	Rowing	Kayaking	Canoeing			
Biceps (mm)	5.9±2.55	7.2±3.49	5.8 ±0.99	0.766	0.504	-
Triceps (mm)	9.1±2.25	9.3±2.71	10.69±1.74	1.351	0.279	-
Subscapular (mm)	9.9±1.71	11.5±3.71	13.51±2.65	3.786	0.038	C* Vs. R
Suprailiac (mm)	11.8±3.21	12.4±5.12	12.35±2.14	0.066	0.936	-
Calf (mm)	10.2±4.12	10.6±3.43	10.76±1.64	0.067	0.935	-
Sum of skinfold (mm)	36.7±8.63	40.4±14.29	53.49±8.47	5.864	0.009	-

Table 4. Comparison of aerobic, anaerobic power and some physical parameters of male rower, kayakers and canoeist

Variables	Rowing	Kayaking	Canoeing	F value (level of significance)	p value
VO2 Max (ml/kg/min)	55.09±4.01	52.26±5.16	48.75±7.30	2.313	0.045
Maximum Anaerobic Power (Watts)	364.50±72.38	364.25±53.89	393.90±56.54	0.527	0.183
Fatigue Index(Watts/Sec)	2.07±0.48	2.04±1.29	2.02±0.58	0.055	0.014
Right Hand Grip Strength (Kg)	42.60±4.38	44.70±8.34	42.50±4.03	0.397	0.677
Left Hand Grip Strength (Kg)	41.60±5.15	44.60±7.30	43.40±4.03	0.660	0.526
Standing Broad Jump (SBJ) (cm)	263.10±20.92	252.75±17.49	258.8±18.33	0.649	0.532
Flexibility (cm)	20.50±4.91	18.00±4.29	12.75±5.12	5.160	0.014
Relative Back Strength	1.89±0.34	1.91±0.21	2.02±0.16	0.634	0.540
Sit Up for 2 min	77.50±9.90	74.00±13.60	82.40±14.0	0.252	0.779
Push Up/min	55.70±9.81	59.60±12.21	72.00±10.63	3.305	0.055
Medicine Ball Throw(Cm)	534.70±55.1	550.57±58.9	554.2±58.79	0.190	0.828

Table 5 represents that body weight and BMI were negatively correlated with maximum anaerobic power (r=-646 and r=-673) and body weight was negatively correlated with average anaerobic power (r=-419).Thigh circumference and mid-arm circumference (MUAC) are positively correlated with minimum anaerobic power(r=0.429) and average anaerobic power at (r=0.432) respectively.

Table 5. Correlations of the physical and anthropometrical parameters of rowers, kayakers and canoeist

Variables	VO2 Max	Max	Min	Average	FI	Hb%
Age	-0.039	-0.151	-0.359	0.007	0.209	0.106
Height	-0.327	0.121	0.266	-0.028	0.112	-0.288
Weight	-0.339	-646**	0.320	-0.419*	0.333	-0.318
BMI	-0.112	-673**	0.142	-261	0.285	-0.108
Fat (%)	-0.285	-332	0.110	0.045	0.304	-0.410*
Arm span (cm)	-0.353	0.040	0.315	-0.306	-0.132	-0.271
Fore leg (cm)	-0.189	-0.075	0.145	-0.583**	-0.261	-0.070
Thigh length (cm)	-0.035	0.015	0.095	0.329	0.258	-0.335
Foot length (cm)	-0.384	-0.086	0.083	-0.225	-0.211	-0.213
Upper arm (cm)	-0.106	-0.001	-0.113	0.091	0.125	0.021
Forearm (cm)	-0.111	0.131	0.254	0.176	0.096	-0.393*
Shoulder Breadth (cm)	-0.175	0.128	0.059	-0.091	-0.004	0.038
Trunk length (cm)	0.095	0.059	-0.270	0.078	0.244	-0.225
Calf circumference (cm)	-0.364	0.319	0.388*	0.079	0.000	-0.173
Thigh circumference (cm)	-0.166	0.236	0.429*	0.374	0.119	-0.137
MUAC (cm)	0.022	0.334	0.107	0.432*	0.187	0.050
Humerus (cm)	-0.385	-0.248	-0.008	-0.143	-0.183	0.304
Femur (cm)	-0.548**	0.155	0.386	-0.107	-0.077	0.055

Discussion

Elite athletes of different sports differ in physical and physiological characteristics and associated with physical training, nutrition, and socio-cultural factors. Rowing is a strength endurance type of sport, and body size and mass are undoubtedly performance related factors (14). 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 (15).

In our present study the height of kayakers was found to be significantly higher than that of rowers and canoeists (Table 1), findings corroborates with that of other study where the kayakers height (184.9±5.8cm) was greater than canoeists (176.9±6.9cm) (16). Height of male rowers of our present study was found to be slightly lower than that has been found in other studies i.e., 181.1±4.9cm (17) and 188.9±3.6cm (18). Body height was found to be significantly higher in case of kayakers than canoeists but their height was found to be significantly lower than their international counterparts as found in other study (19). However, the height of kayakers and canoeist of our present studies were less than that has been found in other study (15). In our present study no significance difference have been found in terms of body weight of rowers, kayakers and canoeists (Table 1) which has been found in other study (16). Also it has been found that sprint paddlers have significantly higher body weight (84.8±6.2kg) than both kayakers (78.1±4.9kg) and canoeists (75.5±8.0kg) (16). Body weight (kg) of male kayakers of our present study was found to be lower than that has been found to be 77.4±8.10kg in the earlier study (19). Body weight of male rowers of our present study was found to be lower than that of other studies in the studies of (14, 18).

BMI of rowers of our study was nearly consistent the findings of other researcher (20). In our present study, in case of kayakers, BMI was found to be more or less same with that has been found in other study (21), but in case of canoeists it is slightly higher (20.64±2.93kg/m^2). BMI of kayakers of our present was found to be slightly higher than that of canoeists (Table 1), which corroborates with the findings of previous study (21), where also the BMI of kayakers (20.94±2.37kg/m^2) was found to be higher than that of canoeists (20.64±2.93kg/m^2). Body fat % of rowers of our study was found to be higher i.e., 10.6±3.6 than other study (17). Body fat% of rowers of our present study reflects the result of the other study (22). Body fat % of kayakers of our present study was found to be slightly higher than that has been found (13.72±3.21) in the previous study (19). Body fat % of kayakers was found to be more or less similar than that has been found 14.4±3.5 in other study (15). Body fat % of our present study was found to be lower than that of the study of other researcher (23). Canoes are designed and built to be paddled with a single bladed paddle and kayaks are made for double bladed paddles. In case of canoeing a single blade paddling gave some muscles a brief rest. Kayakers have their blades in water more of the time, which helps with applying maximum power. In our present study arm span was found to be significantly higher in case of rowers than kayakers and canoeists. Arm span of kayakers of our present study was found to be lower than that has been found in the previous study (23).

In our present study ectomorphic element of rowers were found to be significantly higher than kayakers and canoeist and this contradicts the findings of one of the previous study, where they found greater portion of mesomorphic element in canoeists and smaller portion of ectomorphic element in canoeists than kayakers (16). However, they found significantly higher mesomorphic element in sprint paddler than that has been observed for both canoeists and kayakers. Our present study clearly depicts that endomorphic and mesomorphic elements of kayakers were found to be lower than what was found on Turkish elite Kayakers (19). Ectomorphic element of kayakers was found to be slightly higher than their Turkish counterparts (19).

In our present study the haemoglobin content of rowers was found to be significantly higher than kayakers and canoeists (p=.021) (Table 1). Among a number of factors that affect aerobic capacity, two are of fundamental importance: oxygen transport to skeletal muscles via the cardiovascular system and oxygen consumption. Those factors are often implemented as indices in an assessment of physical performance in athletes. On the other hand, efficient oxygen transport to tissues is further determined by heart size, amount of hemoglobin in the blood circulation system and blood volume (24).

No significant difference has been found between foreleg length, thigh length, foot length upper arm length, shoulder breadth, trunk length, circumference of calf and thigh, width of humerus and femur of rowers, kayakers and canoeists of our present study. Calf circumference of canoeists were found to significantly higher than of both rowers and canoeists at (p=0.002). Mid upper arm circumference of canoeists of our

present studies were found to be significantly higher than both of rowers and kayakers (*p*=0.000).
Mid upper arm circumference (MUAC), thigh circumference and calf circumference of rowers of our present study were found to be less than that has been found in the previous study (14). MUAC (31.4±1.4 cm), thigh circumference (60.2±2.2cm) calf circumference (39.4±2.0cm) of male rowers were found to be higher in other study (18). Shoulder breadth (cm) of kayakers of our present study is more than that has been found in the previous study (23). When holding a kayak paddle, the arms should be at about shoulder width apart and the paddlers box should be maintained for maximum paddling efficiency and safety (25). So greater shoulder width will definitely have a positive effect. Torso length or trunk length of kayakers of our present study was found to be lower than that has been found in other study of whose age group was 20.1±4.67 years. Fore arm length (27.8±3.66cm) and thigh length (50.4±4.71cm) of previous study were found to be lower than that has been found in our present studies (23). Upper arm girth and thigh girth of kayakers of our present study was also found to be higher than the study of other researcher (23). Forearm length of rowers were found to be significantly higher than that of kayakers and canoeist at (*p*=0.001). A short sitting height (relative to stature) and longer limb lengths are characteristic of both lightweight and heavyweight rowers, conferring greater biomechanical efficiency (26). A successful rowing technique requires a maximization of the horizontal direction of rowing (parallel to the water), allowing the largest part of the force to be actually used for propulsion (27).
The two bones, humerus and femurs are greatly involved in rowing. In our present study, diameter of humerus and femurs of rowers was found to be less than that of other study of (18) which was7.5±0.3cm and 10.1±0.6cm, respectively. Diameter of humerus and femur of kayakers of our study was found to be slightly lower than that has been found in a recent study (23) which is 6.5±0.8cm and 9.3±1.7cm, respectively. Both strength and endurance are needed for high-level rowing performance, long hours of rowing-specific training programs combined with weight training typically result in a large aerobic capacity and increased metabolic efficiency, a low percentage of body fat and increased muscle mass (28).
In our present study no significance difference has been found in biceps, triceps, subscapular, suprailiac, calf and sum of skinfolds of rowers, kayakers and canoeists. Skinfold sum provides an index to determine adiposity. For example, subcutaneous fat reflects the amount of fat present in the adipose tissue (29). On the other hand, particular skinfold determination provides information concerning local fat depots and fat distribution in the body (22). Consequently, biceps (3.9±1.0), triceps (7.9±2.2), subscapular (8.9±1.6), suprailiac (6.6±2.2) and calf (8.4±3.0) skin fold measurements of rowers of the previous study were found to be lower than that of our present findings (23). Biceps skinfold measurement of kayakers of our present study was found to reflect the findings of another study (23). Triceps (11.7±3.6mm), sub-scapular (13.1±4.5mm), suprailiac skinfold (14.0±4.6) and calf skin folds (13.6±4.6) measurements of a recent study (23) were found to be higher than that of our present study. A previous study reported that the abdominal and scapular skinfold thicknesses of kayak paddlers were lesser than those of canoes paddlers, but our present study contradicts this thought as there is no significant difference in five skinfold measurements i.e. biceps, triceps, subscapular, suprailiac, calf and in their sum of skinfold of rowers kayakers and canoeists (23). Indeed rowing is a type strength-endurance sport demanding high levels of both aerobic and anaerobic capacities for successful performance. It demands 70-80% aerobic and 20-30% anaerobic capacities for successful performance and also depends on number of oarsmen in the boat, skill level, race distance, and race duration (4). VO_2max i.e., the aerobic capacity of rowers of our present study, was found to be significantly higher than canoeists but lower than that has been found in another study (17).VO_2 max of kayakers of our present study was found to be slightly lower than that has been found in another recent study and that of canoeists of our present study was slightly higher than that has been found in this study (15).VO_2 max of canoeists of our present study was found to be lower than that has been found in a very recent study (30). Fatigue index of RAST test i.e. anaerobic power of rowers of our present study was found to be significantly higher than canoeists at (*p*=.014). In rowing racing takes place over distance of 2000 meters and lasts 5-8 minutes, depending on different types of boat and categories and weather conditions, with a relative amount of energy estimated to be 25-35%from anaerobic and 65-75% from aerobic metabolism (4). Hand grip dynamometry is used to measure the muscular force generated by flexor mechanism of the hand and forearm (31).

Right hand grip strength of kayakers and canoeists of our present study were lower than that has been found in other study (15). In case of standing broad jump no significant difference has been found among rowers, kayakers and canoeists. Flexibility of rowers of our present studies are significantly higher than that of canoeists and kayakers (p=0.14). The method of propulsion of paddling and rowing is completely different. In case of paddling i.e. canoeing and kayaking, paddle strokes are driven by the paddlers torso. The rowing stroke is mainly the function of legs and arms. For allowing the legs to do the work in rowing the seats inside sweep-oar boats and sculls actually slide forward and back to allow the legs to push and the stroke. The seats inside of kayaks, canoes, and rafts are stationary. In canoeing and kayaking paddles propel boats in the same direction as the paddlers is facing. Oars propel the boats in the opposite direction from the way the rower is seated. So, the flexibility of rowers is always high compared to the other two water sports. In our present study no significant difference has been found in the relative back strength of rowers, kayakers and canoeists.

Rowing is primarily a leg-driven activity, while kayaking relies more on the upper body (2). In our present study no significant difference have been found in sit up, push up and medicine ball throw among male rowers, kayakers and canoeists which contradicts the findings of another study in which the physical fitness level exhibited by the kayakers was likewise significantly greater than that of canoeists, both in the counter movement jump and estimated VO_2max (p<0.05), as well as in the overhead medicine ball throw and sit and reach test (p<0.01) (21). Flexibility of kayakers was slightly higher than canoeists which are consistent with the findings another recent study, where the flexibility of kayakers (51.6±7.9cm) was also higher than that of canoeists (49.2±6.9cm) (15).

In a study, the sit up performance per minute of canoeists (34.8±6.2cm) were slightly higher than that of kayakers (33.8±8.0cm), which corroborates with our findings where the sit up performance per two minutes of canoeists were found to be higher than that of kayakers (15). Push up performance per 60 seconds of rowers of the present study was found to be higher than that has been found in a previous study (17). Ball velocity and throwing accuracy are the most important factors for scoring in canoe polo. Medicine ball throw allows for plyometric training of the shoulder (30).

Plyometric however provide a valuable neuromuscular response to training. With repeated plyometric, the subjects CNS becomes habituated to the input from the pectoral is Golgi tendon organs (32). In our present study, table 5 shows that body weight and BMI has a negative significant correlation with maximum anaerobic at (r=-646) and (r=-673), body weight has a significant negative correlation with average anaerobic power at (r=-410) and these contradicts previous studies in which the BMI and lean body mass, along with other basic anthropometric variables such as the stretch stature and body mass have been found to be positively related to better performance not only in kayaking and canoeing (28, 33), but also in rowing (34).

The evaluation and assessment of the present status reveals strengths and relative weaknesses and can become the basis for coaches/trainers to formulate a systematic training programme for improvement in athletes' performance.

Conclusion

The present study reveals that body height of male kayakers was higher than canoeists. Junior rowers have greater arm span than kayakers. Ectomorphic element, hemoglobin content, fore arm length, aerobic power, fatigue index and flexibility of rowers are found to be significantly higher than that of canoeists as the two oars in rowing creates more resistance than paddling. Our findings suggest that factors associated with performance differ according to the competition and type of event. Therefore, it is necessary to implement a different training program depending on the type of event. The findings of this study will be useful to consider while planning the training programs and identifying talented athletes.

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References

1. Steinbright J. (2002). *Qayaqs and Canoes: Native Ways of Knowing* Achorage. Alaska: Alaska Native Heritage Center.

2. Mitchell, J.H., Haskell, W., Snell, P., Van Camp, SP. (2005). Task Force 8: classification of sports. *Journal of American College of Cardiology*; *45*(8): 1364–1367.
3. Gee, T., Olsen, P., Berger, N., Golby, J., Thompson, K. (2011). Strength and conditioning practices in rowing. *Journal of Strength Hand Cond Research;* 25(3): 668-682.
4. Ingham, S.A., Whyte, G.P., Jones, K., Nevill, A.M. (2002). Determinants of 2,000 m rowing ergometer performance in elite rowers. *Eur J. Appl Physiol;* 88: 243-246.
5. Maestu J, Jurimae, T., Jurimae M. (2005). Monitoring of performance and training in rowing. *J Sports Med*; 35: 597-617.
6. A Apostol, A Ionescu, M Vasilescu (2013). Aerobic versus Anaerobic-comparative studies concerning the dynamics of the aerobic and anaerobic effort parameters in top athletes. *Medicina Sportiva*; 9(2): 2130-40.
7. Secher, N.H. (2000). Rowing In RJ Shepherd and P.O. Astrand, (Eds.). *Endurance in sports*. Oxford: Blackwell Science.
8. Baudouin, A., Hawkins, D. (2004). Investigation of biomechanical factors affecting rowing performance. *Journal of Biomechanics*; 37: 969-976.
9. Sodhi HS. Sports anthropometry (1991). *A kinanthropometric approach*. Mohali: Anova Publications.
10. WHO (1995). Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organization Technical Report Series, 854, 1-452.
11. MacKenzie (2005). Performance Evaluation Tests. London: Electric Word place. B.101 pp.44-46.
12. Kavcic, I., Milic, R., Jourkesh, M., Sergej, M., Ostojic, S.M., Ozkol, M.Z (2012). Comparative Study of Measured and Predicted VO2max during a Multi-Stage Fitness Test with Junior Soccer Players. *Kinesiology, 441*, 18-23.
13. Johnson, B.L., Nelson, J.K. (1988). *Practical measurements for evaluation in physical education*. Surjeet Publication, 245-246.
14. Bourgois, J., Claessens A.L., Vrijens, J., Philippaerts, R., Renterghem, B. V., Thomis, M., Janssens, M., Loos, R., Lefevre, J. (2000). Anthropometric characteristics of elite male junior rowers. *British Journal of Sports Medicine*; *34*: 213.
15. Hamano, S., Ochi, E., Tsuchiya, Y., Muramatsu, E., Suzukawa, K., Igawa, S. (2015). Relationship between performance test and body composition/physical strength characteristic in sprint canoe and kayak paddlers. *Open Access Journal of Sports Medicine*; 6: 191-199.
16. Hagner-Derengowska M., Hagner W., Zubrzycki IZ., Krakowiak H., Słomko W., Dzierżanowski M., Rakowski A., Wiącek-Zubrzycka M. (2014). Body Structure and Composition of Canoeists and Kayakers: Analysis of Junior and teenage Polish National Canoeing Team. *Biology of Sports;* 31: 323-326.
17. Arazi, H., Faraji & Mohammadi, S.M. (2011). Anthropometric and Physiological Profiles of Elite Iranian Junior Rowers. *Middle-East Journal of Scientific Research; 9*(2): 162-166.
18. Mikulić, P. (2008). Anthropometric and Physiological Profiles of Rowers of Varying Ages and Ranks. *Kinesiology; 40*(1): 80-88.
19. Akca, A., Muniroglu, S. (2008). Anthropometric-Somatotype and Strength Profiles and On-Water Performance in Turkish Elite Kayakers. *International Journal of Applied Sports Sciences;* 20(1): 22-34.
20. Richter, C., Hamilton, S., Roemer, K. (2011). The Impact of Body Mass And Skill Level on Rowing, Kinematics. *Portuguese Journal of Sport Sciences*; 11(2): 613-616.
21. Plaza, D.L., Alacid, F., Muyor, J.M., Miñarro PAL. (2017). Differences in Anthropometry, Biological Age and Physical Fitness between Young Elite Kayakers and Canoeists. *Journal of Human Kinetics;* 57: 181-190.
22. Garrido-Chamorro, R., Sirvent-Belando, J.E., González-Lorenzo M., Blasco-Lafarga, C., Roche, E. (2012). Skinfold Sum: Reference Values for Top Athletes. *International Journal of Morphology;* 30(3): 803-809.
23. Kaloupsis, V., Dimakoupoulou, E., Zelioti, D., Diamanti,V., Aexiou S. (2012). Selection of Paddle Lengthin Flat-Water Kayak. *Biology of Exercise; 8*(1): 17-26.
24. Martino, M., Gledhill, N., Jamnik, V. (2002). High VO2max with no history of training is primarily due to high blood volume. ***Medicine and Science in Sports and Exercise; 6: 966***–971.
25. Sayour, G. (2017). Muscles and body parts used in kayaking. *American Canoe Association.*
26. Slater, G., Rice, AJ., Mujika, I., Hahm, AG., Sharpe, K., Jenkins, DG. (2005). Physique traits of lightweight rowers and their relationship to competitive success. *British Journal of Sports Medicine*, 39: 736–741.
27. Pollock, C.L., Jenkyn, T.R., Jones, I.C., Ivanova, T.D., Garland, S.J. (2009). Electromyography and kinematics of the trunk during rowing in elite female rowers. *Medical Science Sports Exercise; 41*: 628-36.
28. VanSomeren K.A., Oliver J.E. (2001). The efficacy of ergometry determined heart rates of flat water kayak training. *International Journal of Sports Medicine; 23:* 28-32.
29. Wang Z, Shen W, Withers RT, et al. (2005). Multicomponent molecular-level models of body composition analysis. In: Heymsfield SB, Lohman TG, Wang ZM, et al, eds. *Human body composition*. 2nd edition. Champaign, IL: Human Kinetics, 163–76.
30. Sheykhlouv and M, Bishop P, Khalili E and Karami E. (2015). Anthropometric, Physiological, and Performance Characteristics of Elite Canoe Polo Players .*American Psychological Association;* 8(2): 257–266.

31. Waldo, B. (1996).Grip Strength Testing. *National Strength and Conditioning Association Journal.*32-35.
32. Carp, K.C. (2012).Sensory Integration and Neuromuscular Control of the Shoulder. *Physical Therapy of the Shoulder; 5: 147-162.*
33. Fry, R.W., Morton, A.R. (1991). Physiological and kinanthropometric attributes of elite flat water kayakists. *Medicine and Science in Sports and Exercise; 23*: 1297-1301.
34. Skład M, Krawczy K B, Majle B. (1994). Body build profiles of male and female rowers and kayakers. *Biology of Sports*; 11(4): 249–256.

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