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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

The Relationship of Anthropometric Characteristics of Elite Scullers and Sweep Rowers with Their Sprint Performance Parameters

Elit Tek ve Çift Kürekçilerin Antropometrik Özelliklerinin Performans Parametreleriyle İlişkisi

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Abstract

The aim of this study was to investigate the effects of the anthropometric features of the elite scullers and sweep rowers on their sports performance.

A total of 31 licensed elite male rowing athletes, 10 scullers (age: 21,70 ± 3,30 years; height: 184,2 ± 6,11 cm; weight: 75,28 ± 6,78 kg) and 21 sweep oar rowers (age: 20,95 ± 2,50 years; height: 190,19 ± 5,71 cm; weight: 88,31 ± 8,83 kg), aged between 18 and 26 years with at least 5 years of rowing experience voluntarily participated in the study. In order to determine the rowing performance of the athletes, Oartec rowing simulation machine (Oartec Pty Ltd. Australia) was used. With the help of this simulator, 500 meters sweep

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oar and sculling events were performed race conditions. The data for mean power produced, finish time, stroke number and rate as well as mean speed values were collected from the rowing simulator machine. Before the test, the weight and lean body mass values of the athletes were measured using Tanita SC330 Body Analyzer. The effects of the height, arm span, sitting height, and leg length on performance parameters of the athletes participating in the study were measured. In this study, it was found that the anthropometric values (height, weight, BMI, arm span, leg length and lean body mass) of the sweep rowers are greater than scullers, which positively affects the performances of the sweep rowers.
Keywords: Rowing, anthropometry, performance, oartec rowing simulator

Öz

Bu çalışmanın amacı, çift ve tek kürek branşında elit düzeyde yarışmacı olan kürek sporcularının bazı antropometrik özelliklerinin sportif performans üzerine etkilerinin incelenmesidir. Araştırmaya en az 5 yıl ve üzerinde 18-26 yaş arasında 10 çift kürek çeken (yaş;21,70±3,30 yıl, boy; 184,20±6,11 cm., vücut ağırlığı; 75,28±6,78 kg.) 21 tek kürek çeken (yaş; 20,95±2,50 yıl, boy; 190,19±5,71 cm., vücut ağırlığı; 88,31±8,83 kg.) toplamda 31 lisanslı elit düzeyde kürek sporcusu gönüllü olarak katılmıştır. Kürek çekiş performansının tespiti için Oartec kürek simülasyon aleti (Oartec Pty Ltd. Avustralya) kullanılmıştır. Simülasyon aleti yardımıyla 500 metre mesafede çift ve tek kürek çekme işlemi yarışma şartlarında gerçekleştirilmiştir. Kürek simülasyon aletinde ortalama üretilen güç, bitiriş süresi, kürek sayısı, ortama tempo, ortalama hız verileri elde edilmiştir. Test öncesi sporcuların kilo, yağsız vücut kitlesi ölçümleri Tanita SC330 Vücut Analiz cihazı yardımıyla yapılmıştır. Çalışmaya katılan sporcuların boy, kol açıklığı, oturma yüksekliği, bacak boyu değerleri ile performans parametreleri arasındaki ilişkiler incelenmiştir. Araştırmamızda tek kürek çeken sporcuların antropometrik değerlerinin (boy, kilo, vücut kitle indeksi, kol açıklığı, bacak uzunluğu ve yağsız vücut kütlesi) çift kürek çeken sporculara nazaran daha iyi olduğu ve bu durumun da performans değerlerine olumlu olarak yansıdığı tespit edilmiştir.
Anahtar Kelimeler: Kürek, antropometri, performans, oartec rowing simulator

INTRODUCTION

Rowing is a cyclic sport requiring aerobic and anaerobic capacity where endurance is at the forefront in order to move a boat through the water (Akça, 2014; Gee et al., 2012; Zainuddin, Umar, Razman and Shaharudin, 2019; Sebastia-Amat, Penichet-Tomas, Jimenez-Olmedo and Pueo, 2020). The fundamental principle of the rowing branch, accepted as the fastest water sport in the modern Olympic Games, is to move the boat in the fastest way with the help of rowing (Arslanoğlu et al., 2020). Moreover, the fact that the Olympic competition distance of this sport is 2000 meter complicates the performance demand of this maximum-speed-requiring sport (Soper and Hume, 2004). During each rowing movement, the athlete applies the maximum force he can produce in accordance with the coordination of the movement, since the finish time of the race is a critical performance measure that is determined with the average speed of the boat (Benson, Abendroth, King and Swensen, 2011).

The legs, body and arms of the rowers must work in optimum coordination throughout the entire rowing movement. The feet of the rowers are attached to the stretcher, which is fixed in the boat. With their hands holding the oar handle, rowers perform drive and recovery movements (Černe, Kamnik and Munih, M, 2011; Metikos, Mikulic, Sarabon and Markovic, 2015). They perform this movements during the competition at a stroke rate between 32 and 40 strokes per minute (Martindale and Robertson, 1984). When this movement sequence is examined from a mechanical point of view, it appears that the synchronization of all body segments has an important role. The defining feature of the coordination is the evaluation of the forces produced by the arms, legs and body during rowing (Hill, 2002). In addition, in order for the athletes to perform these synchronization features in rowing, technical-tactical understanding should be considered first, and structural and physiological factors of the body next (Gee et al., 2012).

Rowing competitions with single, double, quad and eight scullers last between 5.5 and 8 minutes, depending on each athlete's sculling and sweep rowing discipline, and the boats have an average speed of about 5.3–6.0 m/s. The performance of the rowers depends on the combined use of high levels of aerobic and anaerobic systems (Domínguez et al., 2020; Benson et al., 2011; Hill, 2002). In order to measure the performances of the rowers, the tests are performed both on dry land and in water. Rowing ergometer comes to the forefront among the tests performed on land. It is used in two ways: as static and as dynamic rower (Zainuddin et al., 2019). While one type of ergometer is suitable for rowing only, regardless of the discipline (sweep rowing or sculling), another type simulates sculling or sweep rowing branches specifically. These ergometers, which can simulate sweep rowing or sculling, allow athletes to perform the movements similar to those on the boat. Therefore, the data from both types of ergometers are intended to evaluate the overall performance of the athletes.

Anthropometric features and body composition of the athletes play an important role in rowing along with other mechanical and physiological factors. The body mass, body shape, length of body parts, musculature, body composition and physical activity levels affect motor abilities of the athletes (Podstawski et al., 2019; Sebastia-Amat et al., 2020; Fohanno, Nordez, Smith and Colloud, 2015). Physical parameters such as body mass and height contribute to absolute muscle strength; however, physiological capacity and endurance are related to training of the athletes (Vanderburgh and Laubach, 2008).

In this study, we aimed to examine the effects of some anthropometric characteristics of rowing athletes, who are elite competitors in sculling and sweep rowing disciplines, on their sportive performance.

MATERIALS AND METHODS

A total of 31 licensed elite male rowing athletes, 10 scullers (age: 21,70 ± 3,30 years; height: 184,2 ± 6,11 cm; weight: 75,28 ± 6,78 kg) and 21 sweep oar rowers (age: 20,95 ± 2,50 years; height: 190,19 ± 5,71 cm; weight: 88,31 ± 8,83 kg), aged between 18 and 26 years with at least 5 years of rowing experience voluntarily participated in this study (Table 3). The study was approved by Marmara University Faculty of Medicine Clinical Research Ethics Committee (protocol number; 092018.458, date; 01.06.2018) and was supported by Marmara University Scientific Research Projects Unit (BAPKO) with project no. SAG-C-DRP-241.018.0577. The subjects were informed about the investigation prior to signing an institutionally approved informed consent document to participate in the study according to the principles defined in Declaration of Helsinki.

Data Collection Method

Oartec Rowing Simulator (Oartec Pty Ltd. Australia) was used in order to determine the performance of the rowing strokes. Sculling and sweep rowing tests were performed under competition conditions using this simulator. The athletes were first tested with regards to their competition specialty branch (scullers or sweep oar rowers). The mean power, finish time, rowing stroke, mean stroke rate and speed values were obtained from the simulator, while baseline, maximal and resting heart rate (at 3 and 5 min) values recorded using the Polar Heart Rate Monitor Watch (S625X). A 10-minute rest period was provided between first and second (sculling or sweep oars rowing) tests. The pre-test warm-up and the resting protocol is shown in Tables 1 and 2.

Table 1. Pre-test warm-up protocol

Warm-up	Duration	Test procedures
Jogging slowly	5 min	Avg. 120-130 heart rate (HR max. percentage about 60-65%)*
Active warm-up exercises	5 min	Low-intensity, active movements Arm, leg, back, abdominal muscle – joint mobility
Pre-test warm-up on the rowing ergometer	5 min	Moderate rowing Avg.140-150 heart rate (HR max. percentage about 70-75%)*
Branch-specific stretching	3 min	Stretching Arm, leg, back, abdominal muscles

*Estimated maximum heart rate calculated as 220 – age

Table 2. Resting protocol between the tests

Warm-up	Duration	Test procedures
Cool down on the rowing ergometer post-test	3 min	Slow paced rowing (<120 heart rate)
Stretching	5 min	Standing and sitting positions
Passive rest/relaxing	2 min	Free

The body weight, lean body mass, body muscle mass, body mass index (BMI) measurements of the athletes were determined using Tanita SC330 Body Composition Analyzer before the test. The height, arm span, sitting height, and leg length values of the athletes participating in the study were measured metrically, and the ages as well as rowing ages of the athletes were noted.

Data Evaluation

Non-parametric Mann-Whitney U test was used to compare the performances and anthropometric characteristics of the athletes, while the Wilcoxon t-test was used for the in-group evaluation of the sculling and sweep oar rowing athletes. Also, Kendall's tau-b correlation analysis was used to compare the performances and anthropometric values of the athletes.

RESULTS

Demographic and anthropometric data of the athletes obtained in the study are shown in Table 3, and their performance values are provided in Table 4.

Table 3. Demographic and anthropometric characteristics of the athletes participating in the study

	Rowing Branches		
	Scullers N = 10	**Sweep Oar Rowers N = 21**	**Total N = 31**
Parameters	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Age (years)	21,70 ± 3,30	20,95 ± 2,50	21,19 ± 2,75
Height (cm)	184,20 ± 6,11	190,19±5,71	188,26 ± 6,40
Weight (kg)	75,28 ± 6,78	88,31 ± 8,83	84,11 ± 10,21
BMI (kg/cm^2)	22,09 ± 1,88	24,45 ± 2,53	23,69 ± 2,57
Arm span (cm)	183,55 ± 6,74	193,71 ± 7,10	190,44 ± 8,40
Leg Length (cm)	93,50 ± 4,06	99,71 ± 4,93	97,71 ± 5,47
Sitting height (cm)	96,00 ± 3,84	97,82 ± 4,01	97,24 ± 3,98
Rowing age (years)	7,90 ± 4,20	6,29 ± 2,17	6,81 ± 3,01
Sports age (years)	9,80 ± 4,78	7,81 ± 2,71	8,45 ± 3,56
Lean body mass (kg)	71,01 ± 4,96	79,81 ± 7,66	76,97 ± 8,00

M: Mean SD: Standart Deviation

Table 4. Performance values of the athletes participating in the study

		Rowers			
		Scullers N = 10	**Sweep Oar Rowers N = 21**	**Total N = 31**	
Parameters	**Branches**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**p**
Average power (Watt)	Sculling	556,53 ± 39,42	589,40 ± 44,37	578,79 ± 44,97	0,069
	Sweep Rowing	527,97 ± 34,78	552,58 ± 43,93	544,64 ± 42,26	0,118
	p	0,022	0,010	0,001	
Finish time (minute)	Sculling	1,23 ± 0,05	1,19 ± 0,05	1,21 ± 0,05	0,072
	Sweep Rowing	1,27 ± 0,05	1,23 ± 0,06	1,24 ± 0,06	0,082
	p	0,008	0,022	0,001	
Stroke (number)	Sculling	47,1 ± 1,91	45,1 ± 3,17	45,8 ± 2,94	0,074
	Sweep Rowing	50,7 ± 2,54	49,2 ± 3,75	49,7 ± 3,44	0,296
	p	0,007	0,000	0,000	
Stroke rate (minute/stroke)	Sculling	33,9 ± 1,41	33,7 ± 1,69	33,8 ± 1,58	0,767
	Sweep Rowing	34,9 ± 1,58	35,2 ± 2,45	35,1 ± 2,18	0,866
	p	0,022	0,005	0,001	
Average speed (m/sec)	Sculling	6,01 ± 0,40	6,28 ± 0,41	6,19 ± 0,42	0,104
	Sweep Rowing	5,76 ± 0,33	6,01 ± 0,42	5,93 ± 0,41	0,128
	p	0,008	0,023	0,001	

Average speed (km/h)	Sculling	21,65 ± 1,44	22,61 ± 1,47	22,30 ± 1,50	0,099
	Sweep Rowing	20,72 ± 1,19	21,64 ± 1,51	21,34 ± 1,46	0,128
	p	0,007	0,022	0,001	
Baseline heart rate	1st test	101,7 ± 7,13	101,5 ± 10,30	101,5 ± 9,28	0,800
	2nd test	105,0 ± 6,88	103,8 ± 7,24	104,2 ± 7,03	0,525
	p	0,041	0,014	0,002	
Maximal heart rate	1st test	176,8 ± 6,88	184,0 ± 9,40	181,7 ± 9,22	0,029
	2nd test	178,8 ± 6,16	184,5 ± 9,16	182,7 ± 8,65	0,072
	p	0,200	0,762	0,324	
Resting heart rate (at 3 min)	1st test	105,5 ± 15,88	113,7 ± 15,52	111,1 ± 15,86	0,69
	2nd test	109,4 ± 17,26	119,4 ± 19,01	116,2 ± 18,78	0,150
	p	0,011	0,014	0,001	
Resting heart rate (at 5 min)	1st test	98,4 ± 15,01	105,1 ± 15,46	103,0 ± 15,40	0,245
	2nd test	103,5 ± 15,52	108,5 ± 17,96	106,9 ± 17,11	0,363
	p	0,009	0,097	0,006	

M: Mean SD: Standart Deviation

When the performance values of the athletes who participated in the study who rowed double rowed and those who rowed alone, there was no statistical difference (p>0,05). A statistical difference was found in all other features except maximal heart rate during double rowing and single rowing of double rowing athletes. (p<0,05). A statistical difference was found in all features except maximal heart rate and resting heart rate (at 5 min) during double rowing and single rowing of single rowing athletes (p< 0,05).

Table 5. Relationships between anthropometric characteristics and some performance parameters of scullers

		Average Power of Sculling	**Average Power of Sweep Oars**	**Finish Time of Sculling**	**Finish Time of Sweep Oars**	**Stroke of Sculling**	**Stroke of Sweep Oars**	**Average Speed of Sculling**	**Average Speed of Sweep Oars**
Age	r	0,613*		-0,596*		-0,532*		0,613*	
	p	0,017		0,022		0,049		0,017	
Height	r	-0,523*		0,506*		0,586*		-0,523*	
	p	0,038		0,046		0,026		0,038	
BMI	r	0,539*		-0,523*				0,539*	
	p	0,031		0,038				0,031	
Average Power of Sculling	r		0,600*	-0,989**	-0,659**	-0,597*		1,000**	0,629*
	p		0,016	0,000	0,009	0,022		0,000	0,012
Average Power of Sweep Oars	r			-0,629*	-0,796**			0,600*	0,764**
	p			0,012	0,002			0,016	0,002

Finish Time of Sculling	r	0,690**	0,604*		-0,989**	-0,659**
	p	0,007	0,021		0,000	0,009
Finish Time of Sweep Oars	r			0,548*	-0,659**	-0,989**
	p			0,035	0,009	0,000
Stroke of Sculling	r				-0,597*	
	p				0,022	
Stroke of Sweep Oars	r					-0,518*
	p					0,045
Average Speed of Sculling	r					0,629*
	p					0,012

Statistically significant difference at *p < 0,05; ** p < 0,01.

Table 6. Relationships between anthropometric characteristics and some performance parameters of sweep oars rowers

		Average Power of Sculling	**Average Power of Sweep Oars**	**Finish Time of Sculling**	**Finish time of Sweep Oars**	**Stroke of Sculling**	**Stroke of Sweep Oars**	**Average Speed of Sculling**	**Average Speed of Sweep Oars**
Age	r						0,401*		
	p						0,018		
Leg Lenght	r		0,416**		-0,405*		-0,453**		0,426**
	p		0,010		0,013		0,006		0,008
Weight	r					-0,354*			
	p					0,032			
Lean Body Mass	r					-0,349*	-0,378*		
	p					0,034	0,020		
Average Power of Sculling	r			-0,974**		-0,564**		0,981**	
	p			0,000		0,001		0,000	
Average Power of Sweep Oars	r				-0,930**		-0,416*		0,933**
	p				0,000		0,010		0,000
Finish Time of Sculling	r					0,553**		-0,974**	
	p					0,001		0,000	
Finish Time of Sweep Oars	r						0,410*		-0,978**
	p						0,013		0,000
Stroke of Sculling	r						0,419*	-0,564**	
	p						0,013	0,001	
Stroke of Sweep Oars	r								-0,436**
	p								0,007

Statistically significant difference at *p < 0,05; ** p < 0,01.

Table 7. The relationships between the anthropometric characteristics and some performance parameters of the rowers participating in the study

		Average Power of Sculling	Average Power of Sweep Oars	Finish Time of Sculling	Finish Time of Sweep Oars	Stroke of Sculling	Stroke of Sweep Oars	Average Speed of Sculling	Average Speed of Sweep Oars
Weight	r					-0,326*			
	p					0,013			
Lean Body	r		0,276*	-0,271*	-0,302*	-0,314*	-0,343**		0,279*
Mass	p		0,030	0,036	0,019	0,017	0,009		0,028
BMI	r					-0,291*			
	p					0,028			
Leg Lenght	r		0,302*		-0,308*		-0,350**		0,300*
	p		0,019		0,018		0,009		0,020
Average Power	r		0,290*	-0,966**	-0,329*	-0,561**	-0,285*	0,964**	0,310*
of Sculling	p		0,022	0,000	0,011	0,000	0,030	0,000	0,014
Average Power	r			-0,307*	-0,878**		-0,425**	0,297*	0,865**
of Sweep Oars	p			0,017	0,000		0,001	0,019	0,000
Finish Time of	r				0,350**	0,553**	0,293*	-0,976**	-0,332*
Sculling	p				0,008	0,000	0,029	0,000	0,010
Finish Time of	r						0,464**	-0,332*	-0,976**
Sweep Oars	p						0,001	0,010	0,000
Stroke of	r						0,413**	-0,542**	
Sculling	p						0,003	0,000	
Stroke of	r							-0,283*	-0,469**
Sweep Oars	p							0,032	0,000
Average Speed	r								0,317*
of Sculling	p								0,012

Statistically significant difference at *p < 0,05; ** p < 0,01.

DISCUSSION

This study was performed to investigate the effects of some anthropometric characteristics of rowing athletes, who are elite competitors in sculling and sweep rowing branches, on their sportive performance. Rowing ergometers are widely used indoors for on-land performance measurements of the rowing athletes. There are two types of ergometers according to their rowing style. The kinematics of the first one consists of a movable seat and a footrest similar to those of boats. In this device, instead of paddles, the handle, which moves back and forth in a plane, is connected to a wheel that creates air or water resistance with the help of a chain cable. This ergometer system does not allow sculling and sweep rowing movements specifically in rowing (Filippeschi et al., 2012). The second form of rowing ergometer is the rowing simulator, which allows sculling and sweep rowing similar to the pulling technique on the boat. This simulator is used in technical training on land as well as to measure performances according to the branches of the athletes. This creates a positive skill transfer to the rowing technique on the boat (Rauter et al., 2013). In our study, a rowing simulator, especially suitable for sculling and sweep rowing technique, was used. Therefore, this simulator provided the opportunity to perform tests similar to the movement pattern of the athletes in the water.

It was stated by Mikulic (2009) and Sulaiman et al. (2016) that the height of the rowers is an important factor directly affecting their performance, and that taller rowers and those who have more lean body mass have also an advantage over their smaller and lighter peers in terms of their performance. In our study, there was a correlation between body weight, lean body mass, body mass index and performance parameters (Tablo 7). It is known that the number of rowing strokes decreases as the athletes' height increases, which allows the blade to sweep more area in the water. Therefore, greater values of the heights, arm spans, and leg lengths can have a positive effect on the rowing performance of the athletes.

In this study, height, body weight, arm span, leg length values and the performance parameters of the scullers and sweep rowers were compared, and it was concluded that the results were greater in favor of sweep rowers. Examining the effect of sitting height on performance, no significant relationship was found among those values (Table 5 and 6), which is similar to the study conducted by Sulaiman et al. (2016).

In our study, it was determined that there was a correlation between the lean body mass values when compared with the average power produced and the finish time of the test (Table 7), which are similar to those in the literature. For example, Majumdar et al. (2017) showed that the body weight of the athletes was significantly related to their performance, and that the athletes with a higher body weight were able to complete the parkour in a shorter time than the lighter athletes did. It has also been reported in the literature that rowers with more lean body mass and muscle mass are associated with better 2000-meter performance time (Huang et al., 2007; Majumdar et al., 2017; Sulaiman et al., 2016). In this study, when we compare the lean body mass values of scullers with those of sweep rowers, it was seen that the results were greater in favor of sweep rowers (Table 3).

When we analyze the average power produced by sweep rowers during sculling and sweep rowing, finish time of the test, average speed, average stroke rate, and the number of strokes, it was determined that the sweepers performed better than scullers (Table 4). It is thought that the better performance values of sweep rowers during sculling and rowing caused by their physical characteristics, especially the height, leg length and arm span values (Table 3).

The Olympic rowing racecourse is 2000 meters long. The first 500 meters of the race is called the sprint phase, in which the boat gains movement from the stationary state. In the ergometer studies, the power generated (363-554 Watts), average stroke rate (37-40 number/min), average speed (4.85-5.81 m/sec), stroke number (57-62 units), transit time (1:26 – 1:43 min) values are reported as performance parameters in 500 meter race (Soper and Hume, 2004; Feros et al., 2012; Egan-Shuttler et al., 2017). In our study, these values (544-578 Watts; 33-35 number/min; 5.93-6.19 m/sec; 45-49 units; 1.21-1.24 min, respectively) were better than the previous studies, and this is thought to be due to the fact that the athletes participating in our study are international-level athletes. During the test, the heart rate of the athletes participating in the study was found to be 181-182 beats/min (bpm). Das et al. (2019) found in their study that the maximal heart rate was 192 bpm at the end of the 2000 m ergometer test and 178 bpm for the first 500 m transition during the test. Mavrommataki et al. (2006) reported that the maximal heart rates of the athletes were between 195 and 197 beats/min during the three consecutive 1000-meter interval loading at the first 500 meter transition. The fact that the maximal heart rate was lower in the ergometer test in our study than those in other studies is thought to be due to the fact that the rowers in our study are both international level athletes and have at least 5 years or more sportive experience.

As a result, in our study, it has been determined that the anthropometric values (height, weight, BMI, arm span, leg length and lean body mass) of the sweep rowers are better than the scullers, and this situation positively affects the performance values of the athletes. Therefore, it can also be concluded that the anthropometric values of the athletes can be directly related to their performance in rowing.

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Authors’ contributions: Design of the study: 1. Author % 40, 2. Author % 15, 3. Author % 15, 4. Author % 10, 5. Author % 10, 6. Author % 10 contributed. All authors have read and approved the final manuscript.

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