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The examination of relationships between upper extremity joint lengths, reaction time and shoulder strength parameters in youth canoe athletes

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Abstract

The aim of this study was to investigate the relationships between upper extremity joint length, reaction time and shoulder strength in young canoe athletes. The study was carried out with the voluntary participation of 23 young canoe athletes. Within the scope of the research plan, height measurements, body weight measurements, length measurements of the upper extremities (arm and forearm length), arm span length measurements, reaction time measurements and isokinetic strength measurements of the athletes were carried out. The effect of joint length values on reaction time and shoulder strength parameters was examined by multiple linear regression analysis. The results show that joint length values have a significant effect on reaction time and shoulder strength values in canoe athletes ($p<0.05$). In conclusion, it is thought that an increase in joint length may also lead to an increase in reaction times.

Introduction

The canoeing discipline is a sport in which athletes compete to complete a race distance in a shorter time than their opponents by rowing with the help of a boat and paddle against the resistance of water. Although the history of canoeing in our country is not very old, it is considered to be a sport that is gaining more interest day by day due to its favorable conditions. In the canoeing discipline, there are many physical and physiological factors that affect the performance of athletes. One of these is considered to be anthropometric characteristics. As in every discipline, achieving success in canoeing also requires the importance of anthropometric, biomechanical, physiological and psychological factors. Knowing how effective these characteristics are in terms of performance plays a critical role in talent selection and performance development (Bishop, 2000). The assessment of these characteristics is considered beneficial for predicting which sports disciplines children and young individuals may be suitable for. It is known that there is a relationship between athletes' anthropometric measurements and their motor performance and those anthropometric characteristics have an impact on performance levels (Özer, 1993).

In the canoeing discipline, in addition to anthropometric characteristics, muscle strength and reaction time (RT) are other important factors that affect athletes' performance. Reaction is the process by which a response to a stimulus received by the central nervous system through nerves is transmitted back to the relevant muscle via nerves, initiating movement. Reaction is one of the crucial coordinative features for quickly and promptly responding to unforeseen situations (Sevim, 2002; Şahin, 1995). In RT, there can be different types of stimuli, such as visual and auditory. It is considered important for athletes to select the correct stimulus among these and respond to it in the shortest possible time, which is crucial for all sports disciplines. RTs, which are essential for athletes, are estimated to be improvable through regular training (Balka, 2018; Çatıkkaş et al., 2011). In canoe sprint, athletes compete in groups during races. It is known that the sooner an athlete responds to the starting stimuli, the greater the advantage they gain over their competitors. From the starting moment to the finish line, muscle strength is one of the important factors for success. At the start, athletes need maximal strength to

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overcome the resistance of the water. After a good start, the important thing is that the athlete can maintain his strength throughout the race. Therefore, it is very important for athletes to have high muscle strength for success.

It is known that isokinetic training is an important method for developing muscle strength. Isokinetic contraction involves the contraction of muscles at a constant speed to complete movements at maximum performance. In isokinetic strength measurements, methods are used where muscles can contract optimally at fixed speeds using specialized devices with predetermined velocities (Bilgiç et al., 2007; Aka, 2018).

Canoeing is considered to be a sport that requires strength and endurance from athletes. When reviewing the literature, it is believed that identifying the basic anthropometric characteristics of athletes for sports requiring strength and endurance is important for athlete health and success. It is anticipated that developing these identified fundamental characteristics will also contribute to success. When examining studies related to canoeing in the literature, it is observed that there is relatively limited information compared to traditional sports such as football, basketball and volleyball. In this context, the aim of the study was to investigate the relationship between upper extremity joint lengths, RT and shoulder strength in young canoe athletes.

Methods

Participants

The population of the study consists of canoe athletes aged 16-18 years. The sample group consists of male canoe sprint athletes licensed in Ordu province within the 16-18 age group. The research was conducted with 23 male athletes actively engaged in canoeing. Parental consent forms were obtained for athletes under 18 years of age.

The details of the study were verbally explained to all athletes and they were informed about the possible benefits and risks of the study. After verbal declaration, a written informed consent form prepared according to the Declaration of Helsinki was given to all athletes and their consent was obtained. In addition, the study was conducted in accordance with the ethical principles of the European Convention on Human Rights and the Declaration of Helsinki (ethical principles of human experimentation) (World Medical Association, 2013) and was approved by the Ordu University Clinical Research Ethics Committee (No: 2021-79).

Table 1
Descriptive data of athletes (n=23).

Variables	Mean	SD	Min.	Max.
Age (years)	17.04	0.87	16.0	18.0
Body weight (kg)	68.71	10.61	46.8	86.1
Height (cm)	173.32	5.81	158.0	182.0

Procedure

Athletes' body weight measurements were taken using a body composition analysis device (Jawon Body Composition Analyzer Model X-Scanplus II, Seoul, Korea) with a precision of 0.1 kg. Measurements were conducted with athletes in an anatomical standing position and barefoot. Height measurements were taken with a stadiometer (Holtain Ltd., Crymych, UK) with a precision of 0.1 cm. Athletes were instructed to stand barefoot on the baseplate with heels together, body and head erect in anatomical position, ensuring a steady posture and the point where the top of the head touched the stadiometer was recorded in centimeters.

Upper extremity joint length measurements

When measuring athletes arm span, they stood upright with their backs straight and arms extended horizontally to each side. The distance between the mid-finger of the left and right hands was measured using a measuring tape and recorded in centimeters. For measuring arm and forearm lengths, athletes' shoulders were kept relaxed, arms in flexion position and forearms held parallel to the ground. Arm length was measured as the distance between the acromion and olecranon bones. Forearm length was measured as the distance between the olecranon and the styloid process of the radius. Holtain sliding calipers (Holtain, Crymych, United Kingdom) were used for arm and forearm length measurements (Zorba & Ziyagil, 1995).

Reaction time (RT) measurement

Before starting RT measurements, no strenuous activity requiring strength was performed to ensure the accuracy of the tests. Measurements were conducted in a well-lit environment without noise. The Moart RT Measurement Device (Lafayette Instrument Co., Sagamore, USA) was used for the measurements. Visual and auditory simple RTs were measured. A distance of

20 cm was maintained between the subject and the reaction machine during measurements. The test started after the preparatory command and athletes responded to the stimulus accordingly. Five measurements were taken for each visual and auditory RT and the first and last measurements were discarded, with the average of the remaining three trials calculated. Measurements were recorded in milliseconds (ms) (Baltacı & Ergun, 1997).

Isokinetic strength measurement

Athletes' upper extremity strength measurements were conducted using an isokinetic dynamometer (Humac Norm, CSMi, Stoughton, MA). Prior to starting the measurements, athletes received detailed verbal and practical instructions. Before the measurement, athletes underwent a dynamic warm-up. Prior to starting the measurement, athletes' personal information was recorded in the measuring device. The dynamometer was adjusted according to the shoulder rotation axis and gravity correction was performed following a pre-established test protocol. Before starting the measurement, athletes were allowed to perform two trial attempts without applying force. Athletes were verbally motivated throughout the measurement process.

Data Analyses

The statistical analysis of the data obtained in the study was conducted using the statistical software package (SPSS 21.0, Armonk, NY, IBM Corp). The conformity of the data to a normal distribution was examined using the Shapiro-Wilk test and it was determined that the data followed a normal distribution ($p > 0.05$). The effect of limb length values on RT and shoulder strength parameters was examined using multiple linear regression analysis. In the multiple linear regression analysis, upper extremity joint length was designated as the independent variable, while RT and shoulder strength values were designated as the dependent variables and regression models were constructed accordingly. Multicollinearity among the independent variables was examined using the Variance Inflation Factor (VIF). Regression models were constructed based on the VIF values. The correlation (r) values obtained from the regression analysis were evaluated as follows: low-level correlation (r = 0.00-0.30), moderate-level correlation (r = 0.30-0.70) and high-level correlation (r = 0.70-1.00). Variables showing a positive (+) correlation indicate a direct relationship, while variables showing a negative (-) correlation indicates an inverse relationship (Büyüköztürk, 2020). The analysis results were interpreted by accepting a significance level of $p < 0.05$.

Results

The mean, standard deviation, minimum and maximum values of athletes' joint lengths, RTs and isokinetic strength measurements were determined. Table 2 presents the measurement results accordingly.

When examining the general regression model in Table 3, it is observed that the parameters related to joint lengths (JL) have a statistically significant effect on predicting the variable of dominant visual RT ($p < 0.05$). Athletes' joint length values explain 25.6% of the variance in dominant visual RT performance ($R^2 = 0.256$). However, there was no statistically significant effect observed between athletes joint length parameters and non-dominant visual RT parameters ($p > 0.05$), indicating that joint length parameters do not explain non-dominant visual RT performance. Additionally, it was determined that joint length parameters do not have a statistically significant effect on dominant and non-dominant auditory RT ($p > 0.05$). Athletes' joint length parameters account for 1% of dominant auditory RT performance ($R^2 = 0.015$) and 1% of non-dominant auditory RT performance ($R^2 = 0.016$).

Table 2
Participants' measurement results (n=23).

Variables	Mean	SD	Min.	Max.
Arm Span (cm)	174.91	5.50	159.0	184.0
Arm Length(cm)	34.98	1.39	31.9	37.5
Forearm Length (cm)	26.42	0.98	24.7	28.0
Dom Visual RT (ms)	444.24	55.34	338.0	541.7
Dom Auditory RT (ms)	384.82	53.03	290.3	506.7
NonDom Visual RT (ms)	446.78	53.73	297.3	521.7
NonDom Auditory RT (ms)	387.21	44.25	311.3	479.7
Dom 60˚/sn Abd (Nm)	47.39	10.66	28.0	62.0
Dom 60˚/sn Add (Nm)	75.52	18.21	34.0	103.0
NonDom 60˚/sn Abd (Nm)	46.69	10.03	30.0	71.0
NonDom 60˚/sn Add (Nm)	75.34	17.83	41.0	107.0
Dom 180˚/sn Abd (Nm)	37.04	5.89	26.0	45.0
Dom 180˚/sn Add (Nm)	61.60	13.45	31.0	81.0
NonDom 180˚/sn Abd (Nm)	37.95	6.27	24.0	49.0
NonDom 180˚/sn Add (Nm)	61.17	14.06	30.0	88.0

Nm: Newton meter; NonDom: Non-dominant; Dom: Dominant; RT: Reaction time; Abd: Abduction; Add: Adduction.

Table 4's analysis of the general regression model reveals that the JL parameters have a statistically significant effect on dominant 60°/s abduction strength ($p < 0.05$). It was found that 31.8% of the torque generated during dominant 60°/s abduction could be explained by the athletes' joint length values ($R^2 = 0.318$). Additionally, it was determined that the athletes arm span had a significant impact on dominant 60°/s abduction strength variables ($p < 0.05$). However, the parameters of arm and forearm length do not have a significant effect on dominant 60°/s abduction strength ($p > 0.05$). The findings indicate that JL parameters do not have a statistically significant effect on dominant 180°/s abduction strength ($p > 0.05$). The JL parameters of the athletes were found to account for only 2% ($R^2 = 0.029$) of the variance in dominant 180°/s abduction strength performance. Moreover, it was determined that JL parameters do not have a statistically significant effect on dominant adduction strength ($p > 0.05$). The athletes' JL parameters explained 4% ($R^2 = 0.048$) of the dominant 60°/s adduction strength performance and only 3% ($R^2 = 0.034$) of the dominant 180°/s adduction strength performance.

Table 3

Multiple regression analysis results between joint length parameters and RT parameters in canoe athletes.

		B	SE	β	t	p	Zero-order r	Partial r
Dom Visual RT								
Constant		1551.732	364.239		4.260	0.000		
Arm span		-4.302	2.596	-0.428	-1.657	0.114	-0.574	-0.355
Arm		-8.334	9.181	-0.210	-0.908	0.375	-0.475	-0.204
Forearm		-2.402	11.880	-0.043	-0.202	0.842	-0.285	-0.046
R= 0.598	R^2= 0.256							
F= 3.524	**p= 0.035***							
NonDom Visual RT								
Constant		1046.450	418.191		2.502	0.022		
Arm span		-0.618	2.980	-0.063	-0.207	0.838	-0.247	-0.048
Arm		-5.504	10.541	-0.143	-0.522	0.608	-0.221	-0.119
Forearm		-11.313	13.640	-0.206	-0.829	0.417	-0.264	-0.187
R= 0.319	R^2= -0.040							
F= 0.717	p= 0.554							
Dom Auditory RT								
Constant		959.804	401.839		2.389	0.027		
Arm span		-4.408	2.864	-0.457	-1.539	0.140	-0.371	-0.333
Arm		5.120	10.129	0.135	0.505	0.619	-0.137	0.115
Forearm		0.642	13.106	0.012	0.049	0.961	-0.179	0.011
R= 0.386	R^2= 0.015							
F= 1.109	p= 0.370							
NonDom Auditory RT								
Constant		934.685	334.914		2.791	0.012		
Arm span		-2.467	2.387	-0.307	-1.034	0.314	-0.373	-0.231
Arm		-4.051	8,442	-0.128	-0.480	0.637	-0.308	-0.109
Forearm		0.978	10.924	0.022	0.090	0.930	-0.148	0.021
R= 0.388	R^2= 0.016							
F= 1.123	p= 0.365							

** $p < 0.05$; r: Correlation Coefficient; R^2: Adjusted R Square; RT: Reaction Time; NonDom: Non-dominant; Dom: Dominant; RT: Reaction time.*

Table 4
Multiple regression analysis results between joint length parameters and dominant strength parameters in canoe athletes.

		B	SE	β	t	p	Zero-order r	Partial r
Dom 60°/sn Abd								
Constant		-140.981	67.229		-2.097	0.050		
Arm span		1.290	0.479	0.666	2.693	0.014*	0.615	0.526
Arm		0.497	1.695	0.065	0.294	0.772	0.428	0.067
Forearm		-2.071	2.193	-0.190	-0.944	0.357	0.137	-0.212
R= 0.641	R^2= 0.318							
F= 4.41	p= 0.016*							
Dom 180°/sn Abd								
Constant		-40.405	44.340		-0.911	0.374		
Arm span		0.394	0.316	0.367	1.246	0.228	0.400	0.275
Arm		0.186	1.118	0.044	0.166	0.870	0.267	0.038
Forearm		0.079	1.446	0.013	0.055	0.957	0.195	0.013
R= 0.402	R^2= 0.029							
F= 1.218	p= 0.330							
Dom 60°/sn Add								
Constant		-144.878	135.577		-1.069	0.299		
Arm span		0.801	0.966	0.242	0.829	0.417	0.360	0.187
Arm		3.305	3.417	0.253	0.967	0.346	0.385	0.217
Forearm		-1.339	4.422	-0.072	-0.303	0.765	0.091	-0.069
R= 0.422	R^2= 0.048							
F= 1.372	p= 0.282							
Dom 180°/sn Add								
Constant		-69.255	100.881		-0.687	0.501		
Arm span		0.656	0.719	0.269	0.913	0.373	0.325	0.205
Arm		2.163	2.543	0.225	0.851	0.406	0.354	0.192
Forearm		-2.256	3.290	-0.164	-0.686	0.501	0.006	-0.155
R= 0.407	R^2= 0.034							
F= 1.259	p= 0.316							

** $p < 0.05$; r: Correlation Coefficient; R^2: Adjusted R Square; Dom: Dominant; Abd: Abduction; Add: Adduction.*

Upon examining the general regression model in Table 5, it was found that the JL parameters did not have a statistically significant effect on non-dominant abduction strength ($p > 0.05$). It was determined that the JL parameters explained 8% ($R^2 = 0.088$) of the non-dominant 60°/s abduction strength performance and only 1% ($R^2 = 0.013$) of the non-dominant 180°/s abduction strength. It is observed that the JL parameters do not have a statistically significant effect on non-dominant adduction strength ($p > 0.05$) and that the JL parameters do not explain the non-dominant 60°/s adduction strength performance.

Discussion

The aim of the study is to examine the relationships between upper extremity joint length, RT and shoulder strength in young canoe athletes. The main finding of this research is that athletes with longer upper extremity joint lengths demonstrate better shoulder muscle strength performance. The analyses indicate that upper extremity joint length significantly influences muscle strength. The second important finding of the study is the positive relationship between upper extremity joint length and RT. It was observed that as the joint lengths of the athletes increase, their RTs also increase.

Table 5
Multiple regression analysis results between joint length parameters and non-dominant strength parameters in canoe athletes.

		B	SE	β	t	p	Zero-order r	Partial r
NonDom 60°/sn Abd								
Constant		-21.142	73.162		-0.289	0.776		
Arm span		1.050	0.521	0.576	2.015	0.058	0.356	0.420
Arm		-0.762	1.844	-0.106	-0.413	0.684	0.176	-0.094
Forearm		-3.376	2.386	-0.330	-1.415	0.173	-0.078	-0.309
R= 0.461	R^2= 0.088							
F= 1.705	p= 0.200							
NonDom.180°/sn Abd								
Constant		-29.684	47.583		-0.624	0.540		
Arm span		0.455	0.339	0.399	1.342	0.195	0.335	0.294
Arm		-0.851	1.199	-0.189	-0.710	0.486	0.070	-0.161
Forearm		0.674	1.552	0.105	0.434	0.669	0.258	0.099
R= 0.384	R^2= 0.013							
F= 1.098	p= 0.374							
NonDom 60°/sn Add								
Constant		-142.028	137.216		-1.035	0.314		
Arm span		0.376	0.978	0.116	0.385	0.705	0.297	0.088
Arm		2.551	3.459	0.200	0.738	0.470	0.294	0.167
Forearm		2.358	4.475	0.130	0.527	0.604	0.223	0.120
R= 0.350	R^2= -0.0016							
F= 0.881	p= 0.468							
NonDom 180°/sn Add								
Constant		-81.211	109.470		-0.742	0.467		
Arm span		0.205	0.780	0.080	0.262	0.796	0.252	0.060
Arm		2.462	2.759	0.244	0.892	0.383	0.303	0.201
Forearm		0.773	3.570	0.054	0.217	0.831	0.139	0.050
R= 0.319	R^2= -0.040							
F= 0.717	p= 0.554							

** $p < 0.05$; r: Correlation Coefficient; R^2: Adjusted R Square; NonDom: Non-Dominant; Abd: Abduction; Add: Adduction.*

The arm span, arm length and forearm length of the young male canoeists included in the study were determined as 174.91 ± 5.50 cm, 34.98 ± 1.39 cm and 26.42 ± 0.98 cm, respectively (Table 2). In a study conducted by Someren (2003), it was observed that the average arm span of the male flatwater canoe national team athletes in the UK was similar to that found in this study. In a study conducted by Akça & Münüroğlu (2007) with the Turkish national team, similarities were observed between the data from this study and their study in terms of arm length and forearm length averages. However, no similarity was found between the average arm span in their study and the arm span data in this study. The lack of similarity is thought to be due to differences in the sample groups in the studies. Ackland et al. (2001) found similarities in forearm length data between this study and their study on male flatwater canoe athletes who participated in the 2000 Sydney Olympics. However, the arm span data did not show parallelism. This difference is thought to be due to the height of the athletes in the study. In a study by Hamono et al. (2015), conducted with 12 canoe athletes who regularly trained and participated in international competitions, similarities were observed between the average joint lengths (arm span, arm and forearm lengths) of the canoe athletes and those found in this study.

In the study, the mean RTs of young male canoe athletes were determined as follows: dominant visual RT averaged 444.24 ± 55.34 ms, dominant auditory RT averaged 384.82 ± 53.03 ms, non-dominant visual RT averaged 446.78 ± 53.73 ms and non-dominant auditory RT averaged 387.21 ± 44.25 ms (Table 2). No studies have been found in the literatures that examine the RT characteristics of canoe athletes using a similar protocol. However, when studies from different sports disciplines are reviewed, similarities can be observed between this study and those conducted with the same protocol. Çırak (2018) reported similar findings regarding the dominant visual RT of athletes in his study, comparable to the results of this research. In the study conducted by Arı et al. (2020) with a young women's football team, the mean RTs of the athletes showed similarities to the RT parameters in this study. However, the findings of Uzaldı (2016) regarding dominant visual RTs in female basketball, football and volleyball athletes do not align with the findings of this study. The differences in data may be attributed to the influence of gender factors.

When examining the peak torque (PT) values of shoulder strength, a negative relationship is observed between angular velocity and RT values. The literature also indicates that as angular velocity increases, PT values decrease (Apaydın & İnce, 2020; Bonatto et al., 2017; Hamano et al., 2015).

No studies have been found that specifically examine the PT values for shoulder abduction and adduction in canoe athletes. However, when studies from different sports disciplines using the same protocol are reviewed, similarities can be observed. The results indicate that the force produced during 180˚/s abduction in the non-dominant extremity (37.95 ± 6.27) is higher than that of the dominant 180˚/s abduction force value (37.04 ± 5.89). For other force values, the dominant extremity was found to generate more force than the non-dominant extremity. In a study by Wilk et al. (1995) with 26 professional baseball players, the differences in shoulder PT values compared to this study may be attributed to differences in the athletes' age averages and anthropometric characteristics. Additionally, similar to this study, the non-dominant 180˚/s abduction value was found to be higher than the dominant 180˚/s abduction value. In the study by Silva et al. (2006) with 23 young elite male tennis players, the higher shoulder PT values compared to this study's data are thought to be related to the athletes' age averages and training levels.

Conclusion

In conclusion, variations in joint length among athletes are likely to impact RT and shoulder strength characteristics. The increased RT in athletes with longer joint lengths may be due to the decreased nerve conduction speed caused by the extended distance between the central nervous system and the fingers. Therefore, it is advisable to consider upper extremity joint length parameters (arm span, upper arm and forearm length) when selecting talent in the sport of canoeing.

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Authors' Contribution

Study Design: MEÇ, Aİ; Data Collection: MEÇ, Aİ; Statistical Analysis: MEÇ, Aİ; Manuscript Preparation: MEÇ, Aİ; Funds Collection: MEÇ, Aİ.

Ethical Approval

The study was approved by the Ordu University of Clinical Research Ethical Committee (2021/79) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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