AÇIK ERİŞİM
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Gazi Beden Eğitimi ve Spor Bilimleri Dergisi
Gazi Journal of Physical Education and Sports Sciences
2023, 28(3), 189-195

Isometric and Ballistic Performance in Canoeing and Weightlifting

Kano ve Halterde İzometrik ve Balistik Performans

Research Article / Araştırma Makalesi

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Received / Geliş Tarihi : 14.01.2023
Accepted / Kabul Tarihi : 11.07.2023
Published / Yayın Tarihi : 31.07.2023

Ethical Statement / Etik Bilgilendirme
This study was approved by the decision of Gazi University Ethics Committee dated 22.03.2022 and numbered 2022-385.

DOI: 10.53434/gbesbd.1234258

Abstract

Weightlifters produce strength and power in the vertical plane, while canoeists produce strength and power in the horizontal plane. The purpose of the study is to examine the difference between isometric strength and ballistic force of athletes in weightlifting and canoeing, at which strength and power production occurs in different planes. 84 athletes aged 14-21 were included in the study. Demographic information of the athletes was taken on a working day and a standard warm-up protocol was applied. Dynamic Strength Index (DSI) was calculated to evaluate the ballistic force. Data for DSI were obtained by Opto-Jump device with counter-movement jump (CMJ) test and Isometric Mid-Thigh Test (IMTP). The IMTP test was performed with the Kistler+Noraxon Measurement Device to evaluate isometric strength. According to the findings of the study, the ballistic force, jump height and DSI values of male weightlifters had higher values than male canoe athletes ($p<0.05$). There was no significant difference between isometric strengths ($p>0.05$). While the jump height and DSI values of female weightlifters were higher than female canoe athletes ($p<0.05$), there was no significant difference between isometric and ballistic strengths. As a result, weightlifters, who produce power in the vertical direction, reveal their strength more clearly in their jumping abilities.

Keywords: Dynamic strength index, Power, Jump, Athlete

Öz

Halter sporcuları kuvvet ve güç üretimini dikey (vertikal) düzlemde gerçekleştirirken, kanocular yatay (horizontal) düzlemde kuvvet ve güç üretirler. Çalışmanın amacı, kuvvet ve güç üretiminin farklı düzlemlerde gerçekleştiği halter ve kano sporlarında sporcuların izometrik kuvvet ve balistik güçleri arasındaki farkı incelemektir. Çalışmaya 14-21 yaş arası 84 sporcu dahil edildi. Sporcuların demografik bilgileri bir iş gününde alınmış ve standart bir ısınma protokolü uygulanmıştır. Balistik kuvveti değerlendirmek için Dinamik Güç İndeksi (DSI) hesaplandı. DSI için veriler Opto-Jump cihazı ile karşı hareket sıçrama (CMJ) testi ve İzometrik Orta Uyluk Testi (IMTP) ile elde edildi. İzometrik kuvveti değerlendirmek için Kistler+Noraxon Ölçüm Cihazı ile IMTP testi yapıldı. Çalışmanın bulgularına göre, erkek halter sporcularının balistik kuvvet, sıçrama yüksekliği ve DSI değerleri erkek kano sporcularından daha yüksek değerlere sahipti ($p<0,05$). İzometrik kuvvetleri arasında ise anlamlı bir farklılık yoktu ($p>0,05$). Kadın halter sporcularının sıçrama yüksekliği ve DSI değerleri kadın kano sporcularından daha yüksek bulunurken ($p<0,05$), izometrik ve balistik kuvvetleri arasında anlamlı bir farklılık yoktu. Sonuç olarak dikey yönde güç üreten halterciler, sıçrama yeteneklerinde güçlerini daha net ortaya koymaktadır.

Anahtar Kelimeler: Dinamik kuvvet indeksi, Güç, Sıçrama, Sporcu

Citation / Atıf : Atalay, G., Kabak, B., Kaya, E. and Deliceoğlu, G. (2023). Isometric and ballistic performance in canoeing and weightlifting. *Gazi Journal of Physical Education and Sports Sciences, 28*(3), 189-195.

Introduction

Weightlifting and canoeing are branches that reveal power on different planes. While power is produced in the vertical plane in weightlifting, power is generated in the horizontal plane in the canoe. In the literature, to the authors' knowledge, there is no study examining the strength differences related to sports branches that produce strength in the vertical and horizontal planes. However, there are studies investigating the effect of ground reaction force (GRF) on speed (Hunter, Marshall & McNair, 2005; Munro, Miller & Fuglevand , 1987). During constant speed operation, there is little or no lateral resistance to be overcome, and the driving forces that increase the forward speed of the body before take-off balance the braking forces that decrease the speed of the body during descent (Munro et al, 1987; Weyand, Sternlight, Bellizzi & Wright, 2000). According to Weyand et al. (2000), runners increase vertical force generation to reach higher speeds. The regression equations show that the mass-specific forces applied against gravity at top speed are 1.26 times greater for faster runners than for slower runners. Nummela et al. (2007) stated that an increase in stride length causes an increase in both vertical force and horizontal thrust. Mero and Komi (1986) also stated that running speed is related to the average net resultant force (vertical and horizontal). There are also numerous hypotheses regarding the relative importance of the various GRF components for sprint performance. Faster running speed is associated with increased vertical force generation (Brughelli, Kinsella & Cronin, 2008; Keller, Weisberger, Ray, Hasan, Shiavi, & Spengler, 1996; Kyröläinen, Belli & Komi, 2001) and there is also an association with horizontal force generation (Munro et al., 1987).

Do the athletes in branches that produce strength in different planes adapt the vectorial structure of the strength in their training? In the context of the question, the hypothesis is put forward that the branches do not consider the force planes. Another hypothesis is that the power and strength forms of the branches are not defined. In other words, the natural strength of the branches and the strength forms of the athletes should match. Thus the purpose of the study is to examine the difference between isometric strength and ballistic force of athletes in weightlifting and canoeing, at which strength and power production occurs in different planes.

Methods

Participants

Forty-five weightlifting (25 male, 20 female) and thirty-nine canoeing athletes (28 male, 11 female), aged 14-21 years, who have been doing sports for at least three years, were included in the study. Power analysis was performed through the G*Power 3.1 analysis program to determine the research group. The relevant analysis, taking the test to be applied within the scope of the study as a reference, 0.05 confidence interval, it was applied at 95% power and small effect magnitude (Cohen, 1988). In this direction, analyses were carried out on a data set of 84 people. The average age of weightlifters was 17.77±1.71 years, and the average age of canoe athletes was 18±3.16. Inclusion criteria for the study; not in the competition period and not having any sports injury in the last six months. Athletes who did not volunteer for the study, were in the competition period and had any sports injuries in the last 6 months were not included in the study.

Study Design

Among the athletes who applied to our institution for the Sports Performance Tests, those who have been involved in weightlifting or canoeing for at least 3 years were evaluated. The independent variables are the branches of the participants (Weightlifting and Canoeing), while the dependent variables are Isometric strength, ballistic force, jump height and DSI. Demographic information of the athletes who volunteered to participate in the study were obtained on the first working day. Athletes who were in the competition period and had a history of sports injury in the last 6 months were not included in the evaluation (n=3).

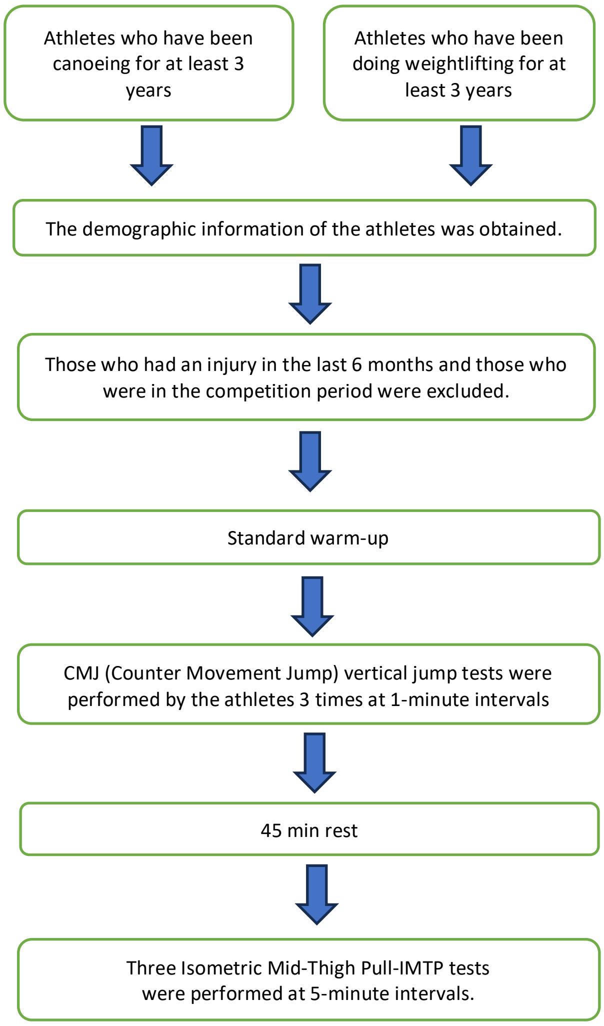

Figure 1: Flow chart of the study

After the demographic information (age, gender, height, weight, sports age) of the athletes was obtained on a working day, a standard warm-up protocol was made. This warm-up consisted of cycling at 60 rpm for 5 minutes on a stationary bike (Monark Exercise 828E, Sweden) followed by static stretches of the lower extremities held for 20 seconds each (Burkett et al., 2005). CMJ (Counter Movement Jump) vertical jump tests were performed by the athletes 3 times at 1-minute intervals using the Opto-Jump device (Glatthorn, Gouge, Nussbaumer, Stauffacher, Impellizzeri & Maffiuletti, 2011). After a 45-minute rest, 3 Isometric Mid-Thigh Pull-IMTP tests were performed with the Kistler+Noraxon Measurement Device at 5-minute intervals (Kawamori, Rossi, Justice, Haff, Pistilli, O'Bryant & Haff, 2006).

Isometric Mid-Thigh Pull Test (IMTP): Following a standard warm-up protocol, the athlete was placed on a force platform with a bar traction device that can be adjusted in height but does not allow movement. The traction bar is adjusted to the middle of the athlete's thigh. The athlete was made to take a squat position with her hips flexed to approximately 145 degrees (Dos' Santos, Thomas, Jones, McMahon & Comfort, 2017), and then the athlete was asked to pull the traction bar with all her/his might. During this pull, the athlete was asked to pull upwards with all his/her strength for 10 seconds, with her shoulders back, chest forward, and looking forward. The measurement was repeated 3 times, with 5 minutes of rest between the tractions, and the highest isometric strength was evaluated.

Counter Movement Jump (CMJ) Test: The Opto Jump test system was used for the test. The athlete was asked to enter the test platform, take the position of the hands on the waist, jump to the maximum height with the command, and complete the jump without bending the knees during the flight and falling to the ground. The optojump infrared platform calculates the jump height by measuring the flight time and then applies the jump height formulas (Glatthorn, Gouge, Nussbaumer, Stauffacher, Impellizzeri & Maffiuletti, 2011). Therefore, the tester does not need to do any calculations. The athlete was asked to do three jumps with 1-minute rest in between and the peak strength value was recorded.

Dynamic Strength Index (DSI): DSI gives the ratio of the highest force an athlete can produce in isometric and ballistic tasks. It measures the difference between an athlete's ability to generate power during an isometric exercise and his ability to generate power during a ballistic exercise (Secomb, Farley, Lundgren, Tran, King, Nimphius & Sheppard, 2015). The result of this measurement allows us to determine the athlete's "power potential" and how much of this potential he/she can use during a high-speed ballistic movement (Weiss, Fry & Relyea, 2002). DSI is calculated by taking the ratio of ballistic PF (peak force) to isometric PF, which is usually evaluated with a vertical jump. Two performance tests are commonly used in DSI calculation. These are the CMJ and IMTP tests (Kawamori, Rossi, Justice, Haff, Pistilli, O'Bryant & Haff, 2006). DSI is calculated from the ballistic force/isometric force ratio (Thomas, Jones & Comfort, 2015).

Ballistic Force (N): Calculated from the following formula (Samozino, Morin, Hintzy & Belli , 2008);

(Bodyweight/2.2) x 9.81 (jump height x 0.025/leg length difference) +1).

Statistical Analysis

Data were analysed using SPSS 21.0 (IBM Corp, Armonk, NY, USA) and results are presented as mean ± standard deviation. The normality of the data was checked with the Shapiro-Wilk test. As a result of statistical analysis, it is seen that the data are normally distributed. The difference between parameters obtained from male and female weightlifting and canoe athletes was compared using Independent samples t-test. The significance value was accepted as 0.05.

Ethics Statement

This study was approved by the Gazi University Ethics Commission with numbered 2022-385. Consent was obtained from the participants that they voluntarily participated in the study. The study was conducted in accordance with the Declaration of Helsinki.

Results

The demographic information of the athletes participating in the research is given in Table 1.

Table 1. Demographic information of weightlifting and canoe athletes in the research group

	Sport	Male			Female		
		N	Mean	*SD*	N	Mean	*SD*
Age (year)	Weight-lifting	25	18.0	1.6	20	17.5	1.7
	Canoe	28	19.0	3.0	11	18.0	3.64
Height (cm)	Weight-lifting	25	172.85	5.62	20	159.37	6.76
	Canoe	28	177.39	6.72	11	167.36	5.02
Body weight (kg)	Weight-lifting	25	80.65	15.04	20	61.00	16.02
	Canoe	28	73.22	10.16	11	60.96	8.06
Training Age (years)	Weight-lifting	25	6.29	2.11	20	5.15	1.95
	Canoe	28	5.85	2.46	11	4.72	2.50

Isometric strength, ballistic force, jump height, and dynamic strength index results of weightlifting and canoe athletes by gender are given in Tables 2 and Table 3.

There is no difference in the isometric strengths of weightlifting and canoe male athletes, while a statistically significant difference is observed in ballistic force, jump height, and DSI values (p<0,05). According to this finding, it was determined that weightlifters had higher values in all three parameters. In the context of athletes producing vertical and horizontal force, the athletes in the weightlifting branch producing force in the axial direction reveal their strength more clearly in their biomechanically similar jumping abilities.

There is no difference in isometric strength and ballistic force of weightlifting and canoe female athletes, while a statistically significant difference is observed in jump height and DSI values (p<0,05). It was determined that weightlifters had higher values in two different parameters. In the context of athletes who produce vertical and horizontal force, the athletes in the weightlifting branch who produce force in the vertical direction reveal their strength more clearly in their biomechanically similar jumping abilities.

Table 2. Comparison of the isometric and ballistic performances of the male athletes

	Sport	N	Mean	*SD*	*t*	*p*
Isometric Strength (N)	Weight-lifting	25	2013.24	224.31	-.565	.575
	Canoe	28	2048.32	226.98		
Ballistic Force (N)	Weight-lifting	25	1908.52	213.87	2.214	.031*
	Canoe	28	1764.71	254.22		
Jump Height (cm)	Weight-lifting	25	38.22	6.56	3.463	.001*
	Canoe	28	32.72	4.87		
DSI %	Weight-lifting	25	98.53	11.59	3.215	.002*
	Canoe	28	89.18	9.56		

*p<0,05

Table 3. Comparison of the isometric and ballistic performances of the female athletes

	Sport	N	Mean	*SD*	*t*	*p*
Isometric Strength (N)	Weight-lifting	20	1589.30	228.17	-.947	.351
	Canoe	11	1666.91	198.06		
Ballistic Force (N)	Weight-lifting	20	1377.45	225.51	.414	.682
	Canoe	11	1346.09	146.70		
Jump Height (cm)	Weight-lifting	20	29.49	4.63	2.754	.010*
	Canoe	11	25.18	3.10		
DSI %	Weight-lifting	20	91.01	7.48	2.022	.043*
	Canoe	11	84.69	9.74		

*p<0,05

Discussion

When the literature is examined, there are no studies comparing isometric force and ballistic power performances in branches that produce force and power in different planes. Canoe and weightlifting athletes prodece strength and power in two different planes, horizontal and vertical. As a result of our study, the ballistic power, jump height and DSI values of male weightlifters were found to be higher than male canoe athletes. In women, the jump height and DSI values of the weightlifters were higher than those of the canoe athletes. We see that weightlifters reach higher jump heights than canoeers despite having more weight and shorter stature. Performance of the vertical jump is largely dependent on factors such as maximal force capacity, rate of force development, muscle coordination and stretch-shortening cycle use (Hackett et al., 2016). Vertical jumping is mechanically similar to weightlifting movements, so the estimated average power and peak power in vertical jump can be correlated with lifting ability (i.e., squat, snatch, and clean and jerk) (Carlock et al., 2004). On the other hand, canoeing is mostly based on aerobic capacity and upper extremity strength (Dokumacı & Çakır-Atabek, 2015). For this reason, we think that the ballistic power and jump heights of canoe athletes are lower.

When weightlifting is examined, it is seen that under the nature of the sport, the extremities reveal movement in the vertical axis and sagittal plane and produce force. Canoeing, on the other hand, creates a vertical axis horizontal force through the movable upper extremity and provides the forward movement of the canoe on the water. Studies have shown that there are some common aspects between snatching and jerking and jumping movements, which are defined as Olympic lifts (MacKenzie, Lavers & Wallace, 2014). In Olympic lifts, it is aimed to change the place of the barbell on the vertical axis by applying a force against gravity, and a movement similar to the vertical jump mechanics is made with the bar. Olympic lifts and vertical jumps in which the stress-shortening cycle is active are functionally quite similar. The focus of vertical jumps is to maximize the displacement of the body along the vertical axis (Storey & Smith, 2012). It was reported that these exercises produced the highest power output among strength and power exercises. Good ability to produce maximum power results in improved athletic performance, such as high vertical jump performance. At the same time, it was stated that the ability to produce maximum power affects the snatch, jerk, and derivatives of the Olympic lift (Cormie, McGuigan & Newton, 2010; Storey & Smith, 2012). Therefore, it is recommended to include one or more of the weightlifting training variants (breaking, shouldering, throws, or pulls) in the strength and power development program to improve jumping skills (Soriano, Suchomel & Comfort, 2019; Suchomel, Comfort & Lake, 2017; Suchomel, Comfort & Stone, 2015). Therefore, the fact that both Olympic weightlifting training improves jumping performance (Ince & Senturk, 2019) and that jumping performance is a predictor of Olympic weightlifting success (Ince & Ulupinar, 2010; Ince, Ulupinar & Özbay, 2020) is accepted as evidence of the bidirectional interaction between these two movements. In our study, it was determined that the ballistic strength and jump heights of weightlifters were better than those of canoe athletes. This situation seems to support the knowledge that it is an important prerequisite to have a similarity between an exercise to be selected and the target sport mechanics for the improvement of training planning and physical performance expressed in the literature.

When we look at canoeing, it is seen that variables such as strength and power are strongly related to canoe performance (Kristiansen et al, 2022; Lum, Barbaso, Balasekaran, 2021). Since power is a product of strength and speed, the relationship between these two factors is very important for canoe performance. While canoe athletes produce force in the vertical axis to provide balance and stabilization while standing and pressing the pedal, they produce force and power in the horizontal plane to move the boat (Lopez & Serna, 2011). Jimenez-Reyes et al. (Jiménez-Reyes, Samozino, García-Ramos, Cuadrado-Peñafiel, Brughelli & Morin, 2018) compared vertical ballistic force-velocity profiles obtained from the vertical jump with horizontal profiles created by sprint performance. Low correlation coefficients were found between this context's theoretical maximum force generation and maximum velocity profiles. Considering the mechanics of the plane or axis used in the sports branch, the importance of testing the athletes was emphasized.

When the sports branches that reveal strength and power in different planes are examined, the effects of gravity force (GRF) should not be ignored. When the vertical and horizontal forces are compared, it has been shown that the magnitude of the vertical forces is greater than the horizontal forces. Munro et al (1987) reported that at velocities between 3.0 and 5.0 m/s, the peak vertical GRF is typically 5-10 times greater than the peak horizontal forces. Looking at the literature, it has been shown that training against GRF increases ballistic strength. Chottidao et al. (Chottidao, Kuo, Tsai, Hwang, Lin & Tsai 2022), in their study on young amateur boxers, showed that vertical jump training improved leg stiffness, jump power, rate of force development, kick velocity, kick force, reaction time, and movement time parameters. Teo et al (Teo, Newton, Newton, Dempsey & Fairchild, 2016) found an increase in the sprint performance, jump height, and agility performance of the athletes after a short-term (6-week) training adopting Olympic-style barbell (WL) exercises and vertical jump (VJ). It is claimed that movements against gravity improve motor abilities by increasing perceptual and physical factors (White, Gaveau, Bringoux & Crevecocur, 2020).

In our study, the jump heights and ballistic strength values of male weightlifters were found to be better than those of canoe athletes. When female athletes are examined, it is observed that the jump heights of weightlifting female athletes and the DSI values they reveal are better. The isometric strength of weightlifters is no better than that of canoe athletes. Despite this, weightlifters produced better DSI values than canoe athletes due to better ballistic strength and jump heights. Many studies in the literature have investigated isometric force performance. Unlike single-joint isometric strength tests, IMTP is often strongly associated with dynamic exercise performance (Kawamori et al, 2006; Nuzzo, McBride, Cormie & McCaulley, 2008). For example, peak force recorded in this test is correlated with: 1RM in the clean-and-jerk, snatch, squat, and deadlift change of direction performance sprinting kinetics and vertical jump height (Stone, O'Bryant, McCoy, Coglianese, Lehmkuhl & Schilling, 2003-a). The importance of isometric maximum strength in various athletic populations has been recognized in the literature, as has been demonstrated in cyclists (Stone, Sands, Carlock, Callan, Dickie, Daigle & Hartman, 2004), track and field athletes (Stone, Sanborn, O'Bryant, Hartman, Stone, Proulx & Hruby, 2003-b), weightlifters (Stone, Sands, Pierce, Carlock, Cardinale & Newton, 2005), college wrestlers (McGuigan, Winchester, Erickson, 2001). There is no consensus on the power required for optimal performance in most sports (Stone, Moir, Glaister & Sanders, 2002). Research shows that the importance of maximum isometric strength in a variety of athletic populations should not be underestimated (Stone et al, 2003-a; Stone et al, 2003-b).

In our study, no difference was found between the isometric strengths of weightlifting and canoe athletes. This situation suggests that isometric strength performance should be expressed with individual differences regardless of the branch. More studies on this subject are needed.

The limitations of our study are:

- Two sports branches that had similar technical content and that produced power on different planes could have been evaluated.
- The number of athletes in the targeted age category of both branches could have been closer.
- Differences in the training planning process (may be in different periods in the strength period, should be questioned

Conclusion

As a result, we see that the weightlifting athletes who produce vertical force show their jumping abilities and ballistic power more clearly than the canoe athletes who produce power in the horizontal plane. In addition, as a result of our research, the fact that canoe athletes have lower ballistic strength profiles than weightlifters can be interpreted as insufficient performance parameters for jump kinematics. Adding vertical exercises to the training programs of canoe athletes can improve their ballistic strength.

As the contribution of the research to sports sciences, it can be said that the forms of strength are studied and the tests and evaluations of the branches specific to this structure are carried out. Trainers, on the other hand, should consider planar differences in the development of strength or power in the process of special strength training. Thus, it can be said that they can make the optimal time and timings more clearly in their periodization.

Financial Support

No financial support was received from institutions and/or institutions during the preparation and writing of this study.

Conflict of interest

There is no conflict of interest between the authors regarding the publication of this article.

Author Contributions

Research Idea: GD; Research Design: BK, GD, GA, EK; Analysis of Data: GD; Writing: GA, BK, GD; Critical Review: BK, GD

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