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Original Article

Concentric isokinetic performance of external and internal rotators of the shoulder in adolescent sprint kayakers

JÉSSICA BONATTO[1], PATRÍCIA PICOLOTTO[1], CAROLINE BOFF[1], ROBERTA ZOTTIS[1], GERSON SACILOTO TADIELLO[1], LEANDRO VIÇOSA BONETTI[1]
[1]Department of Physical Therapy – Universidade de Caxias do Sul – BRAZIL
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Abstract:
Sprint kayak is water sport where stroke is the main movement for the kayak's propulsion, which is composed of cyclic and repetitive movements of the upper limbs. Considering the importance of generating movement and stabilizing the glenohumeral joint during the stroke, a detailed study of the shoulder's muscles is fundamental for improving sports performance and reducing injuries. The main objective of this study is to analyze the muscular performance of external rotators (ER) and internal rotators (IR) in the shoulders of adolescent sprint kayakers. The results demonstrated no significant differences between the limbs, whether for mean ER's and IR's peak torque values or for the external/internal rotators ratio. When analyzing the average values for the male and female sprint kayakers separately, the same results were observed. Conclusions: We concluded that the symmetrical bilateral upper limb demands and the no overhead movements during sprint kayakers' stroke can explain the absence of differences between the limbs' strength and the balance between ER and IR, respectively.
Key Words: kayakers, shoulder, muscle strength, isokinetic evaluation.

Introduction

Canoing is a popular water sport (Michael et al., 2009) and according to the International Canoe Federation (International Canoe Confederation, 2017) there are nine canoe disciplines: sprint canoe, paracanoe, canoe marathon, canoe polo, and dragon boat (performed in flat water), and canoe slalom, wildwater canoeing, canoe freestyle, and ocean racing (performed in white water). Sprint canoe became an Olympic discipline in 1936 (Van Someren & Howatson, 2009) and is divided in sprint canoe and sprint kayak (Michael et al., 2009; Hamano et al., 2015). In sprint canoe, the athlete paddles on one side while kneeling on one knee; in the sprint kayak, the athlete paddles on both sides with a double-bladed paddle in a sitting position with their legs extended anteriorly (Michael et al., 2009; Hamano et al., 2015). Sprint kayakers compete in the individual kayak (K1), as well as the two-seater (K2) and four-seater (K4), over distances of 200, 500, and 1,000 meters (Van Someren & Howatson, 2009; Tay & Kong, 2016). Sprint kayak is a sport in which optimum movement of the craft through the water requires great exertion of the upper body muscles (Sitkowski, 2002; Lemos et al., 2007; Akca et al., 2008; McKean & Burkett, 2010). Therefore, proficient kayakers possess well-developed upper body musculature, including the upper limbs and the trunk (Gobbo et al., 2002; Someren & Palmer, 2003).

The athlete's main movement responsible for the kayak's propulsion through the water is the stroke, which is composed of cyclic and repetitive movements of the upper limbs (Lemos et al., 2007). However, the stroke involves continual use of the same regions of the body, causing overload and increasing the likelihood of injury (Fiore & Houston, 2001; Fiore, 2003; Hensel et al., 2008). The only study performed with elite sprint kayakers showed that 53% of athletes reported having a shoulder injury at the time of testing (Edwards, 1993). These injuries occur due to overloading of the glenohumeral joint and are commonly accompanied by changes in the function of the external and internal rotator muscles of the shoulder (Fiore, 2003; Hagemann et al., 2004).

Considering the importance of generating movement and stabilizing the glenohumeral joint during the stroke of sprint kayakers, the detailed study of the external and internal rotator muscles is fundamental for improving sports performance and reducing shoulder injuries. The device most commonly used for specific muscular evaluations of athletes is isokinetic dynamometry; considered the gold standard method because of its high validity and reliability (Edouard et al., 2013; Bruyère et al., 2016). Specifically, for the shoulder joint, isokinetic evaluation is used extensively, and the two most assessed muscle groups are external and internal rotators (Dvir, 2014). This study aims to analyze, through information from a database, the muscular performance of external and internal rotators in the shoulders of adolescent sprint kayakers.

Material & methods

Participants

This quantitative, cross-sectional and retrospective study was conducted at the Instituto de Medicina do Esporte e Ciências Aplicadas ao Movimento Humano da Universidade de Caxias do Sul (IME-UCS) in the city

Corresponding Author: LEANDRO VIÇOSA BONETTI, E-mail: leandrovbonetti@gmail.com

of Caxias do Sul, Rio Grande do Sul, Brazil. It was approved (protocol number 967.527) by the Ethical Research Committee of the Faculdade Cenecista Bento Gonçalves (Bento Gonçalves, Rio Grande do Sul, Brazil), and conducted according to the 2012 Law Nº 466 of the National Health Council, which approves the guidelines and rules for research involving human beings. The information provided by the IME-UCS database concerning the concentric isokinetic evaluation of the shoulder external rotators (ER) and internal rotators (IR) from 20 adolescent sprint kayakers (13 male and 7 female) from the Prefeitura de Caxias do Sul team occurred in the pre-season was part of this study sample. The number of participants was conveniently established and, therefore, determined intentionally and not by probability according to the number of available evaluations in the IME-UCS's database. Athletes, who had not consented either by themselves or their guardians in the IME-UCS database, were excluded from the study. The mean age of the athletes was 15.25 (± 1.71) years, mean height was 1.67 (± 0.12) meters, mean mass was 63.35 (± 13.83) kilograms and mean body mass index (BMI) was 22.72 (± 2.31) kg/m². For the male athletes, the mean age was 15.08 (± 1.98) years, mean height was 1.68 (± 0.10) meters, mean mass was 61.08 (± 13.96) kilograms and mean BMI was 21.64 (± 2.39) kg/m²; while the mean age of the female players was 15.57 (± 1.13) years, mean height was 1.64 (± 0.13) meters, mean mass was 67.57 (± 13.59) kilograms and mean BMI was 25.12 (± 2.62) kg/m². The mean of the BMI for all players and for the male and female were considered normal, according to World Healthy Organization (2017). All the players reported right upper limb dominance, the average time they had been participating in kayaking was 3.36 (± 2.10) years with an average of 4.40 (± 2.25) hours of training per week.

Procedure

These evaluations were made with the IME-UCS' isokinetic dynamometer (Biodex System 4®, Biodex Medical Systems, Shieley, New York, USA). The athletes first underwent warmup exercises on a stationary bicycle for 8 minutes with no resistance at moderate velocity (70-80 rounds per minute). The athletes were then led through the isokinetic dynamometer. The athletes sat on the dynamometer chair with their torsos at positioned at 85º, and they were stabilized by means of belts around the torso and pelvis to avoid compensatory movements. The positioning of the superior limb to assess the shoulders' external and internal rotators was as follows: 60º shoulder abduction in the scapular plane (30º ahead of the frontal plane) and 90º elbow flexion; the wrist was stabilized to avoid substitution of movement. The amplitude of the movement was limited at 40º external and 50º internal rotation. The order of the tests was conducted randomly, some times the first evaluated limb was the dominant limb (DL) and some times was the non-dominant limb (NDL). The athletes performed three sub-maximal repetitions (50% of their maximum effort) and a previous maximal for each test on the two velocities to familiarize themselves with the procedures and warmup. Protocol during the test demanded 5 and 10 maximal repetitions of shoulder external and internal rotators in concentric-concentric mode on an angular velocity of 60º/s and 180º/s, respectively. A 1-minute rest period was set between evaluations of the two velocities, and a 3-minute rest period between DL and NDL evaluations. Athletes were tested by the same examiner with the use of verbal incentives for stimulation and encouragement to their maximum strength.

Statistical analysis

Isokinetic variables – peak torque (PT, N/m) and the external/internal rotator ratio (ER/IR ratio) (%) – were used for the analysis. The means values for PT and the ER/IR ratio for the shoulder joint musculature were evaluated statistically on the SPSS 17.0 software (Statistical Package to Social Science for Windows). To verify the normality of the data distribution, the Shapiro-Wilk test was used, and the mean values for the DL and NDL tests were evaluated with Student's T test at the significance level of 0.05 for all analysis.

Results

We accessed isokinetic evaluations from 20 adolescent sprint kayakers; 13 males and 7 females. The PT and ER/IR ratio of the DL and DNL are presented in Table 1. At an angular velocity of 60º/s, and 180°/s, the average values for PT and ER/IR ratio showed no significant differences between the limbs. When analyzing the average values for PT and ER/IR ratio for the male and female kayakers separately (Table 2), the same results were observed, and there was no relevant disparity between the limbs in both of the two angular velocities.

Table 1: Mean and standard deviation values for PT and ER/IR ratio of the external and internal rotators' musculatures of the dominant limb and the non-dominant limb's shoulder in sprint kayakers.

Angular Velocities	PT External Rotators (N/m)			PT Internal Rotators (N/m)			ER/IR ratio (%)		
	DL	NDL	"*p*"	DL	NDL	"*p*"	DL	NDL	"*p*"
60º/s	23.22 (±1.93)	22.23 (±1.74)	0.71	35.28 (±3.06)	34.39 (±2.71)	0.83	66.81 (±2.47)	65.76 (±2.81)	0.78
180º/s	22.57 (±1.77)	22.05(±1.44)	0.82	34.27 (±2.92)	32.98 (±2.40)	0.73	66.72 (±1.64)	68.22 (±2.16)	0.58

DL = dominant limb; NDL = non-dominant limb; PT = peak torque; ER/IR ratio = external/internal rotators ratio.

Table 2: Mean and standard deviation values for PT and ER/IR ratio of the external and internal rotators' musculatures of the dominant limb and the non-dominant limb's shoulder in male and female sprint kayakers.

Angular Velocities	PT External Rotators (N/m)			PT Internal Rotators (N/m)			ER/IR ratio (%)		
	DL	NDL	"*p*"	DL	NDL	"*p*"	DL	NDL	"*p*"
					Male (N=13)				
60º/s	25.94 (±2.63)	24.65 (±2.40)	0.72	39.67 (±4,24)	39.02 (±3.43)	0.90	66.56 (±2.85)	62.88 (±2.34)	0.33
180º/s	24.34 (±2.58)	23.98(±1.88)	0.91	37.39 (±4.36)	35.90 (±3.34)	0.79	66.23 (±2.16)	68.27 (±2.34)	0.53
					Female (N=7)				
60º/s	18.16 (±1.31)	17.73 (±0.92)	0.79	27.11 (±0.88)	25.79 (±1.93)	0.54	67.27 (±4.97)	71.10 (±6.64)	0.65
180º/s	18.14 (±1.00)	17.46 (±1.04)	0.64	26.90 (±0.87)	26.34 (±1.96)	0.80	67.57 (±3.10)	67.89 (±4.98)	0.96

DL = dominant limb; NDL = non-dominant limb; PT = peak torque; ER/IR ratio = external/internal rotators ratio.

Discussion

Isokinetic testing provides precise evaluation of muscle performance and the isokinetic dynamometer is very useful for the comparison between the limb strength and the agonistic and antagonistic balance relationship during concentric muscle contraction. Because the muscles of the shoulder joint are stabilizers and motors throughout the range of motion, muscle analysis is extremely important, both in improving performance and in preventing injuries in athletes (Codine et al., 2005; Lugo et al., 2008; Westrick et al., 2013). Many studies have already demonstrated the importance of this articulation during the practice of sprint kayaking, but specific isokinetic studies on the shoulder of canoeing athletes are rare (Humphries et al., 2000). The present study aims to analyze isokinetic performance of the shoulder's external and internal rotators in adolescent kayakers. In the comparison between DL and NDL, the results did not demonstrate any statistically significant difference in the analysis of the PT of ER and IR, nor in the analysis of the ER/IR ratio. When separated by gender, the results also did not show differences between the members in the two angular velocities evaluated.

The study of asymmetries is important in kayakers because a balanced stroke produces more stability and a straighter advancing trajectory of the kayak (Limonta et al., 2010), and imbalances between the limbs indicate a higher risk of injuries. The muscular balance between the limbs can be explained by the sport stroke movement, which for sprint kayakers needs to occur symmetrically between the upper limbs for a better athletic performance. Previous studies have shown that kayakers generate symmetrical paddle forces on the limbs throughout the kayak stroke (Hill, 2002; Michael et al., 2012). In the evaluation of adolescent swimmers, another sport that requires bilateral symmetrical performance of upper limbs, researchers did not observe significant differences between the limbs either (Ramsi et al., 2004). In the study of sprint canoe athletes, in which the demands during the stroke are unilateral, Humphries et al. (2000) did not show significant differences between the members in the analysis of ER and IR; however, they demonstrated isokinetic strength imbalance between the DL and NDL for flexors and extensors of the shoulder joint. Isokinetic studies with adolescent athletes of other sports with unilateral requirements of upper limbs such as volleyball (Franceschini et al., 2016), handball (Dos Santos Andrade et al., 2013), tennis (Ellenbecker et al., 2003; Saccol et al., 2010), and baseball (Noffal, 2003; Hurd et al., 2011), also showed differences between the limbs, with the MD presenting higher values of PT of the ER and/or IR.

Relative to the balance between ER and IR muscles, the ER/IR ratio analyses are important because they reflect muscle function during activity (Yildiz et al., 2006), and serve as a guide for the diagnosis, therapy, and rehabilitation of shoulder lesions (Codine et al., 2005; Schneider et al., 2006). For adolescent athletes, ER/IR ratio analysis is even more important, because they started their sports training early enough to overlap with the period of muscular development (Sciascia & Kibler, 2006), and consequently increase the possibility of rotator muscle-related shoulder injury (Weiss et al., 2013). However, the first analyzed data indicated no significant differences between the DL and NDL average values at the two angular velocities. In addition, almost all of the ER/IR ratio were between 66% to 75%; normative values suggested by Ellenbecker & Davies (2000) for the prevention of shoulder injuries. The NDL of the male athletes at the angular velocity of 60º/s presented a mean value inferior to 66% (62.88%), so that the values of all the athletes also presented a little below (65.76%) the suggested value for this same member and angular velocity. Adolescent athletes of other sports such as handball (Dos Santos Andrade et al., 2014), volleyball (Stickley et al., 2008), and tennis (Ellenbecker & Roetert, 2003) presented values outside normative values. However, the abnormal values cited in these sports occurred due to the presence of overhead and throwing activity, in which there is an increase in the strength of internal rotators without a concomitant gain of strength of external rotators (Ellenbecker & Roetert, 2003; Niederbracht et al., 2008). Conversely, the paddling cycle of kayakers does not involve any overhead or throwing movement

(Hagemann et al., 2004; Niederbracht et al., 2008; Michael et al., 2009; Tay & Kong, 2016). In the first phase, the leading shoulder is stretched forward and the arm is extended, while the active opposite shoulder is moved backward behind the head in abduction, extension, and external rotation; in the second phase, the traction arm flexes and the opposite shoulder adducts with internal rotation, and the corresponding arm is actively pushed forward (Hagemann et al., 2004).

Conclusions

This study demonstrates that the bilateral upper limb demands during sprint kayakers' stroke results in peak torque shoulder's rotators and ER/IR ratio without differences between the DL and NDL in adolescent athletes' analyses. Another result of this study indicated only a few male athletes with ER/IR ratio out of standard values at the angular velocity of 60º/s for the NDL. Although the study of ER and IR shoulder muscles is extremely important for kayakers due to the importance of preventing injuries and improving the motion of the kayak, there is a lack of isokinetic shoulder studies on kayakers to compare the present results. However, we were expecting similar results because the kayaker's stroke has a symmetrical bilateral exigence of the upper limbs and does not present overhead movements to alter the balance between ER and IR. The absence of consensus between athletes from different sports means that isokinetic studies concerning the specificities of kayaking might provide a deeper and more complete muscular description of this selected population. Future studies with a larger sample size, with different angular velocities and different types of muscular contraction, are necessary to confirm our findings and to contribute with the scientific knowledge of this sport modality.

Conflicts of interest: The authors declare no conflicts of interest.

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