Isokinetic performance of knee extensors and flexor muscles in adolescent basketball players

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Summary

Background: Basketball is one of the most popular and most practiced sports in the world, being played by 450 million people worldwide, and the knee is the most commonly injured region of the body involving adolescent male basketball players. Isokinetic dynamometry is generally considered the best protocol for dynamic strength measurements, which are important for preventing musculoskeletal injuries. Therefore, the objective of the present study was to analyze the muscular performance, the unilateral differences and relationships between the knee extensor and flexor muscles in adolescent male basketball players.
Method: The information provided by database concerning the isokinetic evaluation of the knee extensor and flexor muscles from 21 male basketball players under the age of 15 were analyzed. The isokinetic dynamometer was used in a concentric-concentric mode for the knee extensor and flexor muscles at angular velocities of 60°/s, 120°/s, 180°/s, and 240°/s.
Results: The results demonstrated no statistically significant differences between the dominant limb and the nondominant limb at the considered velocities, whether for mean peak torque values or for the flexor/extensor ratio. Another important result showed flexor/extensor ratios within normal values for knee joints.
Conclusions: This study demonstrated that lower-limb dominance does not interfere in the muscular concentric isokinetic performance of the knee extensor and flexor muscles in adolescent male basketball players. We believe that the short time spent in basketball's practice (mean time was 2.46 years) appears to be responsible for these results because the adolescent athletes evaluated in this study did not show differences between limbs, in contrast to studies involving older male basketball players.

Key words:
Muscle strength. Knee. Basketball.

Valoración isocinética de los extensores y flexores de la rodilla de jugadores de baloncesto adolescentes

Resumen

Introducción: El baloncesto es uno de los deportes más populares y más practicado en el mundo, siendo jugado por 450 millones de personas alrededor del mundo. La rodilla es la región del cuerpo más comúnmente lesionada en jugadores de baloncesto adolescentes. La dinamometría isocinética es generalmente considerado el mejor protocolo para medir la fuerza dinámica, que es importante en la prevención de lesiones musculoesqueléticas así como para el seguimiento del entrenamiento deportivo. Por lo tanto, el objetivo del presente estudio fue analizar el rendimiento muscular, las diferencias unilaterales y relaciones entre los músculos extensores y flexores de rodilla de jugadores de baloncesto adolescentes.
Métodos: Se analizó la información de una base de datos en la evaluación isocinética de los músculos extensores y flexores de rodilla de 21 atletas de baloncesto masculino menores de 15 años. El dinamómetro isocinético fue utilizado en modo concéntrico-concéntrico para los músculos flexores y extensores de la rodilla en las velocidades angular de 60°/s, 120°/s, 180°/s y 240°/s.
Resultados: Los resultados no mostraron ninguna diferencia estadísticamente significativa entre el miembro dominante y el miembro no dominante en las velocidades consideradas, tanto para los valores promedio de los pico torque, como para la relación flexores/extensores. Otro resultado importante es que la ratio flexores/extensores mostro valores normales para la articulación de la rodilla de nuestros deportistas.
Conclusiones: El estudio ha demostrado que no hay diferencias entre la extremidad dominante y la no dominante en los valores obtenidos de fuerza isocinética concéntrica de los extensores y flexores de la rodilla de los jugadores de baloncesto adolescentes. Creemos que el poco tiempo empleado en la práctica de baloncesto (el tiempo medio fue de 2,46 años) parece ser responsable de estos resultados, dado que los atletas adolescentes evaluados en este estudio no mostraron diferencias entre los miembros, en contraste con estudios realizados en atletas mayores de baloncesto.

Palabras clave:
Fuerza muscular. Rodilla. Baloncesto.

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Introduction

Basketball is one of the most popular and most practiced sports around the world, being played by 450 million people worldwide[1]. This sport is characterized by sprinting, changes of direction, lateral movement, jumping, and landing[2] as well as repetitive motor actions and excessive-joint load[3]. The large number of injuries in basketball players is linked to running, rapid shifts of movement, and jumping[4,5]. Children and adolescents may be particularly at risk because of their improper technique, poor proprioception, muscle weakness[6], and high volume of intesive trainning[7]. Since the basketball has explosive actions (such as sprints, jumps and innings), knee flexors/extensors force indexes (flexors/extensors ratio or hamstrings/quadriceps ratio) based on the rate of torque development may be useful in assessing joint stability.

Ligament sprains are the most common injury on children[6-8] and adolescent[6,7,9,10] basketball players, and the knee is the most commonli injured region on their bodies[10-14]. This occurs mainly because the demands on the knee from specific sports practices cause specific muscular adaptations and, consequently, imbalances in strength that affect the joint[15]. The quadriceps femoral muscle plays a key role in performing jumps, whereas the hamstrings control running activity and stabilize the knee in situations that involve shifts of direction or attempting a turnover[16].

One of the most active fields of sports medicine research is to determine proper muscular balance – important for preventing injuries – and to specify clear criteria for a return after an injury[17]. Isokinetic dynamometer technology is helping muscular behavior researchers by enabling them to investigate kinetic profiles on athletes. The evaluation of the muscular force is exerted dynamically, at a constant speed and in a certain range of movement. Through a well-structured protocol, it is possible to compare the assessed participants, their normative data, and the generated curves[18]. The results can be used to adjust training techniques in an attempt to prevent traumatic and overuse injuries[19]. Because of a lack of studies related to the evaluation of concentric isokinetic parameters, new research is therefore necessary on a national level regarding adolescent male basketball players. Therefore, the main objective of the present study was to use information from a database to analyse the muscular performance and the unilateral differences and relationships between the knee extensor and flexor muscles of the dominant and nondominant limbs in adolescent basketball players.

Material and method

This is a quantitative, cross-sectional, and retrospective study conducted at the Instituto de Medicina do Esporte e Ciências Aplicadas ao Movimento Humano of the University of Caxias do Sul (IME-UCS), in the city of Caxias do Sul, Rio Grande do Sul, Brazil. It has been 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 N 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 knee extensor and flexor muscles from 21 male basketball players under age 15 from a local team were 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 database. Furthermore, were included evaluations with paternal informed consent of the risks associated with the experimental procedures; which the respective IME-UCS consent term had been authorized by their responsible and by the athletes and athletes with more than 2 years of basketball practice. Were excluded athletes that had the last training on the same day of the test and athletes who reported injuries of lower limbs or acute illness that could disturbed the evaluation.

A questionnaire regarding age, height, weight, dominance, practice time and prevalence of injuries was previously presented to the athletes. The mean age of the athletes was 14.35 years (±0.81), mean height was 1.72 meters (±0.61) and mean weight was 66.78 kilograms (±12.36). With respect to dominance, 19 athletes reported a dominance of the right limb for game movements and only 2 reported dominance of the left limb and the mean time of basketball practice 2.46 years (±1.10). Of all the players, 15 had not sustained injuries in the 45 days prior to the isokinetic evaluation, whereas 6 had suffered injuries both in practice and in competition, particularly involving the knee joints (meniscal and Osgood Schlatter injuries), calf (distension and contusion), ankle (sprain), and foot (fracture). It is also important to observe that only 4 athletes evaluated in the sample practiced regular muscular strengthening activities (weightlifting).

The evaluations were made with the institution's isokinetic dynamometer (Biodex System 4®, Biodex Medical Systems, Shieley, New York, USA). The chosen samples were made between November 2014 and December 2014, in a concentric-concentric mode, for the knee's extensor and flexor muscles at angular velocities of 60°/s, 120°/s, 180°/s, and 240°/s. The athletes first underwent warmup exercises on a stationary bicycle for 8 min with no resistance at moderate velocity (70–80 rounds per minute)".

We believe that it is better to talk a little beat more about the velocity. The athletes were then leaded through the isokinetic dynamometer. The athletes sat on the dynamometer chair with their torsos leaning at 85°, stabilized with belts around the torso, pelvis, and thigh (1/3 distal) to avoid compensatory movements, with the motor axis aligned to the knee joint axis. Tests were first performed on the dominant limb (DL) and next on the nondominant limb (NDL). The athletes performed three sub-maximal repetitions and a previous maximal for each test on all four velocities to familiarize themselves with the procedures and warmup. Protocol during the test demanded 5, 10, 15, and 20 maximal repetitions of knee extension and flexion in concentric-concentric mode on an angular velocity of 60°/s, 120°/s, 180°/s, and 240°/s. A 1-minute rest period was set between evaluations of different velocities, and a 3-minute rest period between DL and NDL evaluations. The athletes were tested by the same examiner with the use of verbal incentives to stimulate them throughout the process and to encourage the maximum use of their strength potential.

Isokinetic variables – peak torque (PT, N/m) to know the function and the flexor/extensor ratio (%) to detect possible deficits of strength and muscular imbalances – were used for the analysis. The means values for PT and the flexor/extensor ratio for the knee 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 evaluations were submitted to Student's t test with a resultant level of significance of 0.05.

Results

The concentric isokinetic data results of the PT of the DL and NDL are presented in Table 1. At an angular velocity of 60°/s, 120°/s, 180°/s, and 240°/s, the average values for PT knee extensor and flexor muscles showed no significant differences between the limbs.

Table 2 shows that there was no significant difference between the DL and NDL average value results of the flexor/extensor ratio for the angular velocities of 60°/s, 120°/s, 180°/s, and 240°/s. No relevant disparity was observed on any of the four evaluated velocities for either the DL or the NDL.

Discussion

Isokinetic testing provides precise evaluation of muscle performance. Nevertheless, for the basketball athletes' evaluation, the fixation of the axes limits the evaluation of a real functional gesture, since in the basketball gestures includes several axes. This sport has explosive actions (such as sprints, jumps and innings), for which good joint stability is desirable. Despite this, the isokinetic dynamometer is very useful for the comparison between the limb strength and the agonistic and antagonistic balance relationship during concentric muscle contraction[19,20]. Over the years, several works concerning a broad set of sports studied the bilateral muscle imbalance and the agonistic and antagonistic ratio (flexor/extensor ratios) of knee joints to provide data about the correct muscular balance of such joints. However, studies on adolescent basketball players specifically are uncommon even though the participants are more vulnerable to the injuries caused by the precocious practice of the sport, are still undergoing neurobiological maturation and growth spurts, and are inserted in a competitive and selective scenario. As several previous studies had already reported, musculoskeletal injuries before isokinetic evaluations demonstrated that the knee was the most commonly injured region[10-14]. According to Louw *et al.*[21], the prevalence of such knee injuries is due to the poor landing mechanism once it is a task that demands good coordination, dynamic muscular control, and flexibility, especially for teenagers whose capabilities are not fully matured. This result indicated that isokinetic evaluation is important for adolescent basketball players and highlights the risk for those injuries and for the optimization of the training process[22].

According to isokinetic analysis, the results of this study were in agreement with those of others adolescent basketball isokinetic studies, demonstrating that at low velocities there are higher PT than at high velocities[23-26]. The evaluations of the muscular PT at low velocities (60°/s) represent the strength capacity a muscle has, whereas high velocities show their muscular potential[26]. By considering both velocities, many times the observation of athletes' muscular performance is better at high velocities because they are equivalent to the sport's practice. The

Table 1. Mean standard deviation values for PT of the extensor and flexor musculatures of the dominant limb and the knee of the non-dominant limb.

Angular velocities	PT knee extensors (N/m)			PT knee flexors (N/m)		
	DL	NDL	*p*	DL	NDL	*p*
60°/s	138.37 (±47.20)	139.20 (±49.73)	0.83	76.29 (±22.18)	76.12 (±22.80)	0.92
120°/s	143.62 (±31.93)	141.97 (±30.53)	0.58	73.40 (±18.57)	75.63 (±18.95)	0.09
180°/s	123.69 (±28.38)	121.90 (±29.54)	0.51	70.60 (±17.38)	67.35 (±20.38)	0.10
240°/s	106.22 (±25.20)	103.44 (±25.19)	0.33	62.56 (±14.37)	63.31 (±18.17)	0.70

DL: dominant limb; NDL: non-dominant limb; PT: peak torque.

Table 2. Mean and standard deviation values for the flexor/extensor ratio of the dominant limb and the knee of the nondominant limb.

Angular velocities	Flexor/extensor ratio (%)		
	DL	NDL	*p*
60°/s	56.45 (±8.78)	56.64 (±10.91)	0.92
120°/s	55.87 (±9.15)	54.29 (±11. 60)	0.41
180°/s	57.94 (±10.51)	56.28 (±14.64)	0.42
240°/s	59.77 (±10.02)	62.10 (±12.83)	0.31

DL: dominant limb; NDL: non-dominant limb.

comparison between DL and NDL showed no significant differences in the mean PT values for the extensor and flexor musculature and in the flexor/extensor ratios. Other studies demonstrated that bilateral asymmetry did not exist in the knee muscle performance of adolescent male basketball players[24,26], whereas bilateral asymmetry was seen in older male basketball players[18,26-30]. Dominance of one limb over the other is a controversial subject[30]. Dominance may be directly associated with the characteristics of each sport, and muscular imbalances may occur when analyzing the flexor and extensor groups bilaterally; however, when considering DL and NDL, strength values of less than 10% are considered normal, and a percentage higher than that indicates a deficit. Many sports require unilateral action during such movements as jumping and changing direction and these movements can develop asymmetric neuromuscular adaptations in the lower extremities[31]. These movements can induce a marked increase in strength on the dominant limb and, consequently, a bilateral difference with the nondominant limb[30]. However, basketball is a sport that requires bilateralism, and bilateral training focuses on training both limbs equally. Consequently, there is a bilateral motor increment. However, the significant differences between limbs in older basketball players can be explained by unilateral jumping over the years[18,31], whereas Schiltz *et al.*[18] claimed that even after years of intense basketball practice, the preferential use of a lower limb for jumping did not induce a bilateral muscle imbalance of the knee. Rosene *et al.*[23] justify that during adolescent athlete training, for the most part, the specific loads upon the lower limbs are sufficient to maintain similar strength on both sides, even unilateral sports like volleyball[16] and soccer[32]. The synergistic action of the involved muscle groups (flexors and extensors of the knee) is necessary for standing, since all activity in load supposes a proportional increase of the force of the agonist-antagonist pair. We really believe that the short time of basketball practice (the mean time of basketball practice was 2.46 years) may help to explain the similar results between the DL and NDL. The comparison between the limbs is extremely important because it provide insights related to injury prevention, performance, and rehabilitation[33]. Previous studies have linked bilateral strength imbalance with a great risk of injury in basketball players[33] and the most appropriate strategy for reducing the injury risk is the identification and understanding the muscular performance[34]. If not identified, the bilateral limb imbalance can affect the athletic performance[34] through the changes in the biomechanical of movement and posture[35].

In relation to knee joint flexor/extensor ratio analysis, no significant differences were observed between DL and NDL, and its mean values vary very little from one to the other. Studies by Buchanan and Vardaxis[24] and by Hadžić *et al.*[26] also demonstrated no flexor/extensor ratio differences between DL and NDL in young male basketball players. The evaluations of the knee's functional capacity and the knee joint's muscular balance are provided by the flexor/extensor ratio that, according to the studies, is approximately 60%[36,37]. Santos *et al.*[38] state that values under this percentage, when in lower velocities, shall make the athlete more prone to developing some kind of injury. However, this study's results showed that, as velocities increased, so did the flexor/extensor ratio. Since the performance of the flexors are higher at medium-high velocities because of its greater percentage of muscular fibers type II than the extensors of the knee. During activities performed at high velocities, muscular stability is crucial; at lower velocities, instability is actually well balanced, whereas compensation decreases as velocities increase. Knee's flexors and extensors strength indices (flexor/extensor ratio) based on the PT of the concentric contraction have traditionally been used to describe the possible destabilization of the knee joint. Most likely in the basketball practice, which has the explosive actions cited, analyze the flexor/extensor ratio in high velocities are interest in order to assess joint stability. Also of important is that imbalance in the flexor/extensor PT ratio is correlated with a greater incidence of lower-extremity injury[39] and is an important parameter for choosing the correct intervention by health professionals involved with the athletes[38]. These results allow our group of athletes to insist on the need to strengthen the flexors muscles, since they do not reach 60% although they are close.

This study demonstrated that there are no differences between the mean DL and the NDL values for knee extensor and flexor PT and flexor/extensor ratios in adolescent basketball players, with the mean values obtained on the isokinetic evaluation being varied very little between both knees. This study also showed strength balance between flexor and extensor PT, demonstrated through the flexor/extensor ratio analysis. We believe that the time spent practicing appears (mean time was 2.46 years) to be responsible for these results because the adolescent athletes evaluated in this study did not show differences between limbs, unlike studies with older male basketball players. This study is important because there are few studies[24,26] that evaluate adolescent male basketball players, male basketball playeirs, and that ones, evaluates just, differently of our study that utilized 4 different angular velocities. Another important factor is that the literature do not present normal parameters for the most utilized velocities in different ages, sports practices and types of contractions and our study can collaborate with this lack of literature. Therefore, the absence of consensus related to athletes from different sports means that isokinetic studies concerning the specificities of basketball might provide a deeper and more complete muscular description of this selected population. However, we suggest that future studies should be conducted to expand knowledge related to isokinetic muscular function evaluation on adolescent male and female basketball players, using different angular velocities, and isokinetic eccentric and isometric contractions for a better knowledge of the muscular balance of the joints of the basketball athletes.

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