

# Isokinetic performance of knee extensor and flexor musculature in adolescent female handball players

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## Summary

**Background:** Handball is a sport that requires an extensive variety of movements and has led to an increased incidence of ankle and knee injuries. Specifically, to knee joint, detection and reduction in muscular deficits can help prevent injuries and improve muscular performance. Isokinetic dynamometer is a highly effective and trustworthy assessment tool for such detections. Therefore, the objective of this study was to analyze muscular performance, and the differences between dominant and non-dominant limb of the knee extensors and flexors in adolescent handball athletes.

**Method:** Data of isokinetic evaluation of knee muscles of 19 female handball players was obtained from a database and analyzed. The isokinetic dynamometer was used in a concentric-concentric mode for the knee extensors and flexors at angular velocities of 60°/s, 120°/s, 180°/s and 240°/s.

**Results:** Mean values of peak torque or the flexor/extensor ratio were not statistically significant in the comparison between the limbs at any of the angular velocities. Furthermore, the flexor/extensor ratio values were between 50% and 80% that are described as normal in the literature of knee joint.

**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 handball athletes. Consequently, it can be suggested that handball athletes present lower risk of knee injuries when compared to sports that lead to some type of muscular asymmetries.

**Key words:**  
Handball. Knee.  
Muscle strength.

## Valoración isocinética de la musculatura extensora y flexora de la rodilla de jugadoras de balonmano adolescentes

### Resumen

**Introducción:** El balonmano es un deporte que requiere una gran variedad de movimientos; en consecuencia, se ha demostrado que aumenta la incidencia de lesiones en el tobillo y la rodilla. Específicamente, para la articulación de la rodilla, la identificación y reducción de los déficits musculares pueden ayudar a prevenir lesiones y mejorar el rendimiento muscular. El dinamómetro isocinético es un método de evaluación de alta efectividad y confiabilidad para este tipo de identificación. Por lo tanto, el objetivo de este estudio fue analizar el rendimiento muscular y las diferencias entre los miembros dominantes y no dominantes de los extensores y flexores de la rodilla de jugadoras de balonmano adolescentes.

**Métodos:** Se obtuvieron datos sobre la evaluación isocinética de los músculos de la rodilla de 19 jugadoras de balonmano femenino. El dinamómetro isocinético se utilizó en modo concéntrico-concéntrico para los músculos extensores y flexores de la rodilla en las velocidades angulares de 60°/s, 120°/s, 180°/s y 240°/s.

**Resultados:** Tanto los valores medios del pico de torque como la relación flexores/extensores no fueron estadísticamente significativos entre los miembros en ninguna de las velocidades angulares. Además, la relación flexores/extensores estaban entre el 50 y el 80% que se describen como normales en la literatura para la articulación de la rodilla.

**Conclusiones:** Este estudio demostró que el dominio de los miembros inferiores no interfiere con el desempeño concéntrico isocinético de los músculos extensores y flexores de la rodilla en adolescentes practicantes de balonmano. En consecuencia, se puede sugerir que los atletas de balonmano tienen un menor riesgo de padecer lesiones de rodilla en comparación con los practicantes de otros deportes que causan algún tipo de desequilibrio muscular.

**Palabras clave:**  
Balonmano. Rodilla.  
Fuerza muscular.

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## Introduction

Handball is a sport that requires an extensive number and variety of movements; jumps, settings, accelerations, changes of direction, and passing are the most frequent gestures of this sport<sup>1-5</sup>. As a consequence of these characteristics, some epidemiological studies demonstrate that handball has an increased incidence of musculoskeletal injuries<sup>6-9</sup> and the ankle and knee joints are the most affected areas<sup>7,9-14</sup>. This increased incidence has also been documented in young female athletes<sup>14-15</sup>. Due to the physical consequences, and the long period away from the sport, the knee injuries have been in the spotlight in recent years, especially the anterior cruciate ligament (ACL) injuries<sup>16</sup>. According to Lohmande *et al.*<sup>17</sup>, there is an increased incidence of ACL injuries in adolescent athletes from sports that involve the pivot movement such as in handball and the female athletes present an even higher risk<sup>18</sup>.

Thus, assessing, identifying and reducing muscular deficits in the knees can help to prevent injuries<sup>7,11,15,19</sup>, to improve muscular performance and to improve sporting gestures in handball athletes<sup>1,5,20</sup>. An important tool for this kind of identification is the isokinetic dynamometer, an assessment method that is highly effective and reliable<sup>21</sup>. Although, several studies have used the isokinetic assessment for muscular analysis in different sporting populations and joints, only a few studies have focused on its use for knee joint assessment of handball athletes<sup>22-27</sup>, while none of them focused on adolescent female handball athletes. Therefore, the purpose of this study was to analyze, through information from a database, the muscular performance and differences between the dominant and non-dominant limbs of the knee extensor and flexor musculature in adolescent female handball 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 da Universidade de 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.

For this study, the IME-UCS' database was used to obtain information regarding the concentric isokinetic evaluation of the knee extensor and flexor muscles. The study sample included 19 adolescent female handball players from the Universidade de Caxias do Sul team who were under age 16 and under age 18 categories. 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. The evaluations in which the respective IME-UCS consent term had not been authorized by the athletes and their responsible were excluded from this study. Athletes had a mean training experience of 5.38 years ( $\pm 6.82$ ), mean age of 15.37 years ( $\pm 1.83$ ), mean height of 1.67 meters ( $\pm 0.09$ ), mean weight of 61.41 kilograms ( $\pm 9.68$ ) and a mean body mass index (BMI) of 21.89 kg/m<sup>2</sup> ( $\pm 2.31$ ), which is con-

sidered normal<sup>28</sup>. The players self-reported their preferred upper limb for throwing a ball as their dominant upper limb and their preferred lower limb for kicking a ball as their dominant lower limb. All the 19 athletes reported the right upper and lower limb as their dominant limb (DL) and their left upper and lower limb as their non-dominant limb (NDL).

The evaluations data in the IME-UCS' database was collected using the isokinetic dynamometer (Biodex System 4®, Biodex Medical Systems, Shiley, New York, USA). The athletes first underwent warmup exercises on a stationary bicycle for 8 minutes at moderate velocity (70–80 rounds per minute) and then were led through the isokinetic dynamometer. Subsequently, they sat on the dynamometer chair with their torsos leaning at 85° with the motor axis aligned to the knee joint axis. They were stabilized with belts around the torso, pelvis, and thigh (1/3 distal) to avoid compensatory movements. Tests were first performed on the DL and next on the NDL. The range of motion for testing was set from 10 to 90° of knee flexion, where 0° is the full knee extension. 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 maximal repetitions of knee extension and flexion in concentric-concentric mode on an angular velocity of 60°/s, 10 for the 120°/s, 15 for the 180°/s, and 20 for the 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. Athletes were tested by the same examiner with the use of verbal incentives to stimulate and encourage them to use their maximum strength potential throughout the process.

Isokinetic variables – peak torque (PT, N/m) and the flexor/extensor ratio (%) – were used for the analysis. The flexor/extensor ratio is calculated from the PT value of the flexors divided by the PT value of the extensors. The mean values for PT and the flexor/extensor ratio of the knee joint musculature were evaluated statistically using 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 the Student's T-test at a significance level of 0.05.

## Results

We accessed isokinetic evaluations from 19 adolescent female handball players. The concentric isokinetic data results (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 outlines the flexor/extensor ratio at the angular velocities of 60°/s, 120°/s, 180°/s, and 240°/s. No significant differences were found between these mean ratios in the DL and NDL at any angular velocity. Furthermore, it was determined that all flexor/extensor ratio values were between 50% and 80% that are considered normal in the knee joint literature.

## Discussion

Over the years, several studies have analyzed the knee joint musculature in athletes of various sports to elucidate balance of muscular

**Table 1. Mean and standard deviation values for PT of the knee extensor and flexor musculature of the dominant and non-dominant limbs.**

Angular velocities	PT knee extensors (N/m)			PT knee flexors (N/m)		
	DL	NDL	"p"	DL	NDL	"p"
60°/s	143.59 ± (39.72)	144.69 ± (33.92)	0.75	75.35 ± (20.27)	72.36 ± (18.52)	0.23
120°/s	116.44 ± (27.35)	116.28 ± (24.96)	0.94	65.83 ± (15.64)	60.23 ± (16.07)	0.11
180°/s	97.54 ± (19.33)	96.92 ± (21.42)	0.72	55.07 ± (10.42)	52.98 ± (11.70)	0.26
240°/s	79.78 ± (14.10)	81.72 ± (17.28)	0.46	50.28 ± (8.70)	47.91 ± (10.47)	0.14

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

**Table 2. Mean and standard deviation values for the knee flexor/extensor ratio of the dominant and non-dominant limbs.**

Angular velocities	Flexor/extensor ratio (%)		
	DL	NDL	"p"
60°/s	52.47 ± (7.44)	50.23 ± (7.45)	0.25
120°/s	56.78 ± (6.70)	52.38 ± (11.85)	0.12
180°/s	57.23 ± (9.28)	55.63 ± (11.64)	0.46
240°/s	64.05 ± (11.95)	60.45 ± (17.35)	0.12

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

characteristics between the limbs and knee joint. The musculature balance between the limbs as well as the extensors and flexors are important for decreasing the rate of musculoskeletal injuries<sup>29-30</sup>, especially in female athletes<sup>31</sup>. Nonetheless, studies on adolescent handball players are uncommon in spite of young athletes and handball amateur players presenting higher rates of musculoskeletal injuries caused by the precocious practice of the sport<sup>32</sup>. Therefore, the purpose of this study was to analyze the isokinetic performance of the knee extensor and flexor muscles of female adolescent handball players. For limbs' comparison, the assessment of muscle strength (through mean PT values) and the agonist/antagonist balance (flexors/extensors ratio) are important parameters to be considered by any sports team<sup>33-34</sup>. Significant or greater than 10% differences between limbs are indicative of muscle imbalance and asymmetry of the knee extensor and flexor muscles and have been observed in young non-athlete women<sup>35</sup>. However, PT of extensors and flexors, and flexor/extensor ratio analysis between the DL and NDL, in this study, indicated no imbalance and asymmetry at both angular velocities.

These results are in accordance with other isokinetic studies of handball athletes<sup>22,23,25-27,36</sup>. Specifically in comparison with adolescent female athletes, there are no similar studies in order to have any comparison. Nonetheless, the literature presents some studies in which young female adults with a mean age of 20<sup>23,26,36</sup> and 26 years were assessed<sup>26</sup>. Lund-Hanssen *et al.*<sup>36</sup> and Xaverova *et al.*<sup>26</sup> assessed high-level athletes at angular velocities of 60°/s and 240°/s, whilst Kazazović *et al.*<sup>23</sup> assessed amateur athletes at angular velocities of 60°/s and 180°/s. The findings of these studies are similar to this present study as they did not demonstrate any significant differences between the limbs when analyzing mean PT and flexors/extensors ratio of the knee musculature. Male elite professional<sup>22,25,27</sup> and amateur<sup>23</sup> handball players also did not demonstrate any significant differences between the limbs in the assessment of these muscle groups at angular velocities of 60°/s and 180°/s.

Although, knee's muscle comparison between the limbs is important and it is the most mentioned method to identify muscular imbalances<sup>37-38</sup>, the characteristics of the handball practice needs to be considered during the analysis of these results. Unlike handball, sports that require unilateral action of the lower limbs may develop asymmetries and muscular adaptations in the lower limbs<sup>39-40</sup>. Sports such as soccer<sup>28,41</sup>, basketball<sup>42-44</sup> and volleyball<sup>25,45-46</sup> demonstrate significantly higher PT values and flexors/extensors ratio in the DL during assessment of the knee extensor and flexor muscles. The dominance of one limb in relation to the other is a very controversial matter and can be associated with the characteristics of each sport. Recently, the literature review by McGrath *et al.*<sup>47</sup> confirmed that the differences between the limbs should be primarily attributed to specific neuromuscular demands from each sport.

Another noteworthy finding of this study is the mean PT values of the adolescent athletes, which are inferior to other results of young female handball athletes<sup>23,26,36</sup>. This result had already been expected and we believe it is associated to the short training experience and to the age of the athletes evaluated in this study. The players evaluated in this study presented shorter mean training experience time (5.38 years) when compared to the others studies with young female athletes that reported a mean training experience of 7.9<sup>23</sup> and 11.5<sup>26</sup> years. In regards to age, De Ste Croix<sup>48</sup> states that anthropometric, neurological, and hormonal changes from childhood and adulthood are directly related to muscle strength alterations and, consequently, to the results of an isokinetic assessment.

Regarding the ratio flexor/extensor ratio analysis, the results of this study ranged between 50% and 64% for both limbs. These values are within normal range of 50-80% for the knee joint according to literature and are mainly dependent on the angular velocity<sup>49-50</sup>. In contrast, Kim and Hong<sup>51</sup> state that there is a tendency indicating that values lower than 60% are associated with noncontact lower limbs injuries. The higher values of the flexors/extensors ratio at higher velocities which were found in our study are in agreement with previous results from female handball athletes<sup>36,52</sup>, and they have already been shown in previous studies<sup>50,53-55</sup>. The analyzed flexors/extensors ratio in this study refers to the conventional ratio which is calculated from the concentric PT value of the flexors divided by the concentric PT value of the extensors<sup>56</sup>. This parameter basically indicates whether there is balance between the anterior and posterior thigh muscles; it has been extensively studied and it is used to describe the possible destabilization of the knee joint<sup>57</sup>.

This study found no differences in the knee extensor and flexor PT values or flexor/extensor ratios between DL and the NDL. Furthermore,

flexor/extensor ratios were between normal values in adolescent female handball athletes. We believe that these results are due to the muscular demands imposed on these muscle groups during the handball practice, which unlike in other sports, occurs symmetrically between the limbs and flexor and extensor muscles of the knee. Knee's bilateral (dominant and non-dominant limb comparison) and ipsilateral (flexors and extensors comparison) balance is a good indicator of lower risk of musculoskeletal injuries. Thus, it can be suggested that playing handball presents lower risk of knee injuries when compared to sports that lead to some type of muscular asymmetries. Although other studies have already shown results of isokinetic assessments of handball athletes, this study is the first to show results of adolescent female athletes. Further research may use different angular velocities, and isokinetic eccentric and isometric contractions for a more thorough knowledge of muscular balance; these will expand the knowledge related to isokinetic muscular function evaluations in adolescent female handball players.

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