

# Bilateral asymmetry of knee and ankle isokinetic torque in soccer players u20 category

## *Assimetria bilateral no torque isocinético do joelho e tornozelo em jogadores de futebol da categoria sub 20*

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**Abstract** – Bilateral asymmetries and muscle imbalances are associated with increased risk for lower limb injuries and still seem to imply in athletes performance. This study aimed to analyze bilateral asymmetry of soccer players in age category below 20 years old (peak torque and conventional and functional reason in extensor/flexors of knee and inverter/eversion of ankle) and to compare these variables between defending, midfield and attacker players. The study included 22 athletes in age category below 20, which underwent a five maximal isokinetic testing with repetitions at 180°/s for knee and 120°/s for ankle, both concentric and eccentric actions. T test for dependent data was used to compare values of torque between dominant and non-dominant limbs and one-way ANOVA was used to compare neuromuscular variables between players of different positions, both at  $p < 0.05$ . No significant differences were observed in any neuromuscular variable (peak torque and functional and conventional ratio) between dominant and non-dominant sides ( $p > 0.05$ ). It was found that defensive players had eccentric torque values of extensors knee higher than midfield players ( $p < 0.05$ ). Defensive players exhibit greater eccentric torque of knee extensor muscles compared to midfield players. It can be concluded that the analyzed soccer players did not present bilateral asymmetries in flexor/extensor knee muscles neither in inverter/eversion ankle muscles.

**Key words:** Asymmetry index; Injury; Muscle imbalance; Soccer.

**Resumo** – As assimetrias bilaterais e os desequilíbrios musculares estão associados com o risco aumentado para lesões nos membros inferiores e ainda parecem implicar o desempenho dos atletas. Assim, este estudo objetivou analisar a assimetria bilateral de jogadores de futebol da categoria sub 20 (pico de torque e razão convencional e funcional dos extensores/flexores do joelho e inversores/eversores do tornozelo), além de comparar tais variáveis entre jogadores defensores, meias e atacantes. Participaram deste estudo 22 atletas da categoria sub 20, que foram submetidos a um teste isocinético com cinco repetições máximas a 180°/s para o joelho e 120°/s para o tornozelo, ambos com ações concêntricas e excêntricas. Utilizou-se o teste t para dados dependentes para comparar os valores de torque entre os membros dominante e não-dominante e ANOVA one way para comparar as variáveis neuromusculares entre jogadores de diferentes posições, ambos a  $p < 0,05$ . Não foram observadas diferenças significativas em nenhuma variável neuromuscular (pico de torque e razão funcional e convencional) entre os lados dominante e não-dominante ( $p > 0,05$ ). Foi verificado que os jogadores defensores apresentavam valores de torque excêntrico nos extensores do joelho, superiores aos meias ( $p < 0,05$ ). Os jogadores que atuam na defesa apresentam maior torque excêntrico nos extensores do joelho, quando comparados aos jogadores de meio-campo. Pode-se concluir que os jogadores analisados não apresentaram assimetrias bilaterais nos músculos flexores/extensores do joelho, bem como nos inversores/eversores do tornozelo.

**Palavras-chave:** Desequilíbrio muscular; Futebol; Índice de assimetria; Lesão.

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## INTRODUCTION

Soccer is a sport in which the energy supply is predominantly aerobic, considering the total effort time. However, it has intermittent characteristics, allowing performing high-intensity actions such as sprints with constant accelerations, decelerations, jumps and kicks, requiring high energy demand from anaerobic systems<sup>1</sup>. In view of these characteristics, neuromuscular properties such as ability to produce force and power in the lower limbs is considered an important determinant for the performance of soccer players<sup>2-4</sup>.

During a soccer game, players often perform different actions, many of which are unilateral such as kicks, passes and movements to change the running direction in order to achieve greater success in carrying out these actions<sup>12</sup>. It has been reported that the performance of continuous and prolonged acyclic actions with asymmetrical motor pattern may cause force deficit between two segments (bilateral asymmetry) or among agonists / antagonists muscle groups of the same segment (muscle imbalance)<sup>5,6</sup>.

Fousekis et al.<sup>6</sup> reported that muscular asymmetry may be related or be dependent on age or training time of athletes and playing positions. Young players tend to be more asymmetric than more experienced players due to more balanced use of forces of the lower limbs by the latter, which may be a preventive neuromuscular strategy in relation to the process of specialized training<sup>5,6</sup>. Some results suggest that the position or function performed in the field can also promote asymmetries in muscle function between lower limbs, which could impair performance during game actions<sup>11</sup>. Silva et al.<sup>4</sup> observed differences in muscle power of lower limbs among soccer players, according to their position in the field<sup>3</sup>, in which defenders were more powerful than midfielders, probably due to the higher number of high-intensive tasks such as jumps and short-distance sprints<sup>4</sup>. However, it is not clear whether there is difference in knee and ankle muscle torque and levels of asymmetry among players of different positions.

An important aspect to be highlighted is that bilateral force asymmetries and imbalances in power capacity between agonist and antagonist muscles have been associated with increased risk for muscle injuries in the lower limbs<sup>6,7</sup>. Among these, hamstring muscle strains<sup>7</sup> and injuries in the knee ligaments<sup>5,6</sup> are the most reported in soccer players<sup>7,5,6</sup>. This type of injury commonly occurs in team sports athletes during the performance of maximum sprints, more specifically, during the final phase of the free leg swinging in step cycle, time at which hamstrings eccentrically act to slow down the leg and control knee extension<sup>11,12</sup>. According to Small et al<sup>13</sup>, power imbalance between hamstrings and quadriceps is the main risk factor for muscle injuries<sup>14</sup>.

Additionally, it has been reported that differences above 15% of torque between dominant and non-dominant limbs is considered an increased risk of muscle injury<sup>8-11</sup>, but there is no consensus in literature about these values<sup>15</sup>. The analysis of these values can be an important tool to assist in

developing strategies to reduce the risk of muscle injury, seeking a correct prescription of training loads and control of the rehabilitation process<sup>4,6,9,16</sup>.

In this context, this study aimed to: i) analyze bilateral asymmetry of soccer players U20 category, considering concentric and eccentric peak torque (PT) and conventional and functional ratio of knee extensors / flexors and ankle evensor / inverter muscles; ii) compare isokinetic torque variables among players of different positions (defenders, midfielders and forwarders). Thus, it was hypothesized that young athletes would show bilateral asymmetries and that there are differences in isokinetic PT according to the position in the match.

## METHODOLOGICAL PROCEDURES

### Subjects

Twenty-two soccer players U20 category aged 18-20 years participated in this cross-sectional study, with practice time  $8.0 \pm 1.3$  years, body mass  $74.0 \pm 7.1$  kg, height  $177.8 \pm 6.5$  cm and fat percentage  $10.7 \pm 1.9\%$ , belonging to a professional soccer club in the city of Florianópolis, SC, Brazil. Athletes trained on average five times per week for approximately 90 minutes. The following inclusion criteria were used: 1) to train at least 5 times a week; 2) not be injured at the time of collection; 3) to sign the informed consent form. Goalkeepers were excluded from the sample due to their training specificity and function performed in the field. The sample selection was non-probabilistic and intentional type, with volunteer participation. Sample size was calculated based on the effect size = 0.5 (moderate effect) and  $p = 0.05$ , set at minimum power of 80% of the statistical analysis.

Subjects were informed about the research objectives and methods before starting the data collection procedures and then signed the informed consent form, which presented the agreement with conducting evaluations. This study was approved by the Ethics Committee for Research with Human Beings of the local university under protocol No: 724427.

### Data collection procedures

Soccer players were evaluated in two stages. Initially, anthropometric measurements were performed and then the knee and ankle isokinetic torque evaluation of dominant (DOM) and nondominant limbs (NON-DOM). Dominant limb was considered as that that the athlete reported having a preference to make technical movements such as control or passes.

### Knee isokinetic torque evaluation

Athletes performed a 5-minute warm-up exercise on a cycle ergometer with average power of 25 W. Then, each athlete was positioned and stabilized on the isokinetic dynamometer (Biodex System 4, one Chicago, USA), according to manufactures' recommendations. The chair backrest inclination was maintained at 85 °, the knee epicondyle was aligned with the dynamometer's rotating axis and the lever arm holder was fixed two fingers above

the malleolus medialis of the tibia. The motion range was maintained at 90° of flexion from the full knee active extension. Athletes were evaluated by an experienced researcher who, through verbal command, encouraged them throughout the test for maximum force performance.

The protocol applied for the knee isokinetic torque measurement was performed as follows: to familiarize in the angular velocity of 180°/s, three submaximal voluntary contractions in the concentric / eccentric mode (CON / EXC) of knee extensors were performed. After 120 seconds, five maximal voluntary contractions in CON / EXC mode of the same muscle group were performed, which were considered for analysis. The same procedures were followed for the isokinetic torque assessment in the eccentric / concentric mode (EXC / CON) of knee flexors. The protocols were performed in both legs, always starting with DOM. In both protocols (CON / EXC and EXC / CON), peak torque (PT) was considered as the highest value obtained in five replicates using the Biodex System software 4. The conventional ratio was calculated using the ratio between  $PT_{CON}$  of flexors and  $PT_{CON}$  of extensors. The functional ratio was calculated by the ratio between  $PT_{EXC}$  of flexors and  $PT_{CON}$  of extensors.

In addition to PT, the asymmetry index (AI) between dominant and nondominant limbs was calculated, as proposed by Kobayashi et al<sup>13</sup>:

$$AI = \{(PT_{dom} - PT_{ndom}) / (+ PT_{dom} + PT_{ndom})\} \times 100 (\%)$$

### Ankle Isokinetic torque evaluation

Athletes remained sat with chair backrest kept at 70°, knee positioned between 30° and 45°, fixation support at the calf height and ankle with 35° of plantar flexion. The dynamometer shaft was aligned with the lateral malleolus, according to manufactures' recommendations. The motion range was maintained at 55° from maximum active eversion.

For isokinetic torque measurement, a protocol similar to that described for the knee joint was used, with three submaximal voluntary contractions for familiarization, followed by 5 maximal voluntary contractions in CON / EXC (ankle inverters) and EXC / CON (ankle everters) modes, angular velocity of 120°/s and rest interval of 120 seconds between them.

The selected angular velocities (180°/s<sup>-1</sup> for knees and 120°/s<sup>-1</sup> for ankles) have been widely used to evaluate muscle strength in soccer players<sup>6,8,12,14</sup>, as they favor the force-velocity relation of muscles and provide more applicable information on muscle power. Eccentric contractions can better simulate the joint stabilization function held during the various actions of the soccer game<sup>15</sup>.

The evaluation was performed by an experienced researcher who, through verbal command, encouraged them throughout the test for maximum force performance. In order to standardize the protocol, the joint of the dominant segment was firstly evaluated and then the joint of the nondominant segment, soon after knee evaluation. PT was obtained using

the Biodex System software 4 and the highest value obtained on 5 replicates was considered. Conventional ratio was calculated using the ratio between  $PT_{CON}$  of ankle eversors and  $PT_{CON}$  of ankle invertors and the functional ratio was calculated using the ratio between  $PT_{EXC}$  of ankle eversors and  $PT_{CON}$  of ankle invertors.

## Statistical analysis

Data was presented using descriptive statistics (mean and standard deviation). Data and residue normality was tested using the Shapiro-Wilk test. The t test for dependent data was used to compare the torque values between dominant and nondominant limbs and analysis of variance (one-way ANOVA) with post hoc Tukey to compare neuromuscular parameters (peak torque, muscle ratios and asymmetry index) among players of different positions (defenders, midfielders and forwarders). Significance level set at 5% was adopted for all tests and the software used for analysis was SPSS Statistics 17.0.

## RESULTS

Table 1 shows the isokinetic torque values of knee extensor and flexor and ankle invertor and eversor muscles in concentric and eccentric muscle action of dominant and nondominant limbs. No significant differences were found in knee and ankle peak torque between lower limbs.

**Table 1.** Isokinetic torque parameters of knee extensor/flexor and ankle invertor/eversor muscles in concentric and eccentric muscle action in the dominant (DOM) and nondominant limb (NON-DOM) and asymmetry indexes (% AI) between segments.

	DOM	NON-DOM	AI (%)	P
<b>Knee</b>				
$PTE_{CON}$ (N.m)	190.66 ± 37.74	197.56 ± 38.07	6.28 ± 4.79	0.29
$PTE_{EXC}$ (N.m)	286.17 ± 63.22	287.40 ± 71.94	9.66 ± 7.78	0.93
$PTF_{CON}$ (N.m)	130.02 ± 32.36	128.45 ± 28.70	6.38 ± 7.44	0.72
$PTF_{EXC}$ (N.m)	162.80 ± 50.17	161.40 ± 40.91	10.09 ± 11.06	0.90
$F_{CON}/E_{CON}$	0.68 ± 0.14	0.65 ± 0.10	--	0.32
$F_{EXC}/E_{CON}$	0.86 ± 0.26	0.82 ± 0.17	--	0.47
<b>Ankle</b>				
$PTEV_{CON}$ (N.m)	38.06 ± 9.42	38.93 ± 11.58	7.87 ± 7.75	0.75
$PTEV_{EXC}$ (N.m)	40.03 ± 13.15	39.58 ± 12.89	8.61 ± 8.24	0.89
$PTINV_{CON}$ (N.m)	41.80 ± 12.01	43.26 ± 10.07	10.63 ± 7.98	0.46
$PTINV_{EXC}$ (N.m)	41.40 ± 9.49	39.93 ± 11.58	13.25 ± 8.14	0.37
$EV_{CON}/INV_{CON}$	0.94 ± 0.19	0.92 ± 0.24	--	0.80
$EV_{EXC}/INV_{CON}$	0.97 ± 0.20	0.93 ± 0.27	--	0.60

$PTE_{CON}$ : Concentric PT of knee extensors;  $PTE_{EXC}$ : Eccentric PT of knee extensors;  $PTF_{CON}$ : Concentric PT of knee flexors;  $PTF_{EXC}$ : Eccentric PT flexors of knee flexors;  $F_{CON}/E_{CON}$ : knee conventional ratio;  $F_{EXC}/E_{CON}$ : knee functional ratio;  $PTEV_{CON}$ : concentric PT of ankle eversors;  $PTEV_{EXC}$ : eccentric PT of ankle eversors;  $PTINV_{CON}$ : Concentric PT of ankle invertors;  $PTINV_{EXC}$ : Eccentric PT of ankle invertors;  $EV_{CON}/INV_{CON}$ : ankle conventional ratio;  $EV_{EXC}/INV_{CON}$ : ankle functional ratio.

Table 2 shows the torque parameters in the knee extensor and flexor and ankle invertor and evertor muscles in concentric and eccentric muscle action on the dominant limb of defenders, midfielders and forwarders. There was a significant difference only in eccentric PT of extensor muscles ( $PTE_{EXC}$ ), and defenders showed higher values than midfielders, but showed no difference from forwarders.

**Table 2.** Isokinetic torque parameters of knee extensor/flexor and ankle invertor/evertor muscles of the dominate limb of defenders, midfielders and forwarders.

	Defenders (n= 6)	Midfielders (n= 7)	Forwarders (n=8)	P
<b>Knee</b>				
$PTE_{CON}$ (N.m)	209.58 ± 31.07	166.22 ± 36.77	197.85 ± 35.4	0.08
$PTE_{EXC}$ (N.m)	344.85 ± 39.06	241.51 ± 56.76#	281.23 ± 50.95*	0.006
$PTF_{CON}$ (N.m)	147.85 ± 22.15	118.67 ± 41.54	126.58 ± 27.34	0.26
$PTF_{EXC}$ (N.m)	197.90 ± 42.17	138.64 ± 45.82	157.61 ± 49.51	0.09
$F_{CON}/E_{CON}$	0.71 ± 0.11	0.69 ± 0.18	0.64 ± 0.13	0.69
$F_{EXC}/E_{CON}$	0.97 ± 0.32	0.83 ± 0.22	0.82 ± 0.26	0.54
<b>Ankle</b>				
$PTEV_{CON}$ (N.m)	40.25 ± 7.01	40.98 ± 13.77	33.86 ± 4.82	0.28
$PTEV_{EXC}$ (N.m)	41.98 ± 9.13	45.74 ± 17.49	33.58 ± 9.44	0.19
$PTINV_{CON}$ (N.m)	40.15 ± 6.25	46.47 ± 15.46	38.95 ± 12.09	0.46
$PTINV_{EXC}$ (N.m)	40.30 ± 3.35	44.24 ± 13.66	40.27 ± 8.88	0.68
$EV_{CON}/INV_{CON}$	1.01 ± 0.16	0.89 ± 0.94	0.93 ± 0.27	0.57
$EV_{EXC}/INV_{CON}$	1.05 ± 0.19	0.99 ± 0.14	0.90 ± 0.25	0.41

$PTE_{CON}$ : Concentric PT of knee extensors;  $PTE_{EXC}$ : Eccentric PT of knee extensors;  $PTF_{CON}$ : Concentric PT of knee flexors;  $PTF_{EXC}$ : Eccentric PT flexors of knee flexors;  $F_{CON}/E_{CON}$ : knee conventional ratio;  $F_{EXC}/E_{CON}$ : knee functional ratio;  $PTEV_{CON}$ : concentric PT of ankle evertors;  $PTEV_{EXC}$ : eccentric PT of ankle evertors;  $PTINV_{CON}$ : Concentric PT of ankle invertors;  $PTINV_{EXC}$ : Eccentric PT of ankle invertors;  $EV_{CON}/INV_{CON}$ : ankle conventional ratio;  $EV_{EXC}/INV_{CON}$ : ankle functional ratio. \* Significantly different from defenders and midfielders. # Significantly different from defenders.

## DISCUSSION

The first aim of this study was to analyze the bilateral asymmetry of soccer players U20 category (peak torque and conventional and functional ratio of knee extensors / flexors and ankle invertors / evertors). According to results, there was no difference in torque variables between dominant and nondominant limbs, as well as in conventional and functional ratios, thus rejecting the hypothesis of this study. It had been hypothesized finding force asymmetries, as soccer players almost never use both limbs with the same emphasis, focusing on the dominant limb<sup>17</sup>. Analyzing the AI values, it was observed that they are within normality standards suggested in literature (less than 15%)<sup>6,8-10</sup>. This result may have been influenced by the methodology used in the training of these athletes, who are encouraged to perform technical movements with both limbs, avoiding the exclusive use of the dominant limb.

Studies evaluating force asymmetries in soccer players have often shown divergent results<sup>8,14,16,18</sup>; however, there is a tendency for the non-

dominant limb to present higher eccentric PT values of knee flexors and extensors and concentric PT values of knee flexors. On the other hand, the dominant limb tends to present higher values in the eccentric torque of flexors, which is in agreement with results found in this investigation. These differences are possibly related to the different muscle functions between dominant and nondominant limbs during the match actions, which exert, for example, in the kick moment, eccentric force of the knee extensors, while applies concentric force of this muscle group in the contralateral limb. These characteristics may lead to differences in overloads received by muscle groups during training / matches<sup>12</sup>. The superiority of the  $PT_{EXC}$  of knee flexors in the dominant limb was observed in other studies<sup>14,16,18</sup>, which could be justified by the specific actions of this muscle group, such as when making passes, there is a concentric contraction of knee extensor and eccentric contraction of flexor muscles in the dominant limb. This action promotes distinct adaptations in flexor muscles as to develop greater capacity to produce eccentric force, as this contraction plays a key role in protection and stabilization of the knee joint, thus avoiding the anterior tibial translation in relation to the femur, especially in end angles of knee extension during intense contractions of extensor muscles<sup>19</sup>.

Even though our study found no bilateral asymmetry, literature has reported that bilateral force asymmetry, particularly eccentric force (>15%) and agonist / antagonist muscle imbalances are considered risk factors for injuries<sup>9</sup>. It has been reported that asymmetries seem to be related with age and practice time in sport. According to Fousekis et al<sup>6</sup>, older players have lower force asymmetry and higher force indexes compared to young athletes, as these athletes possibly use in a more balanced manner forces as a neuromuscular preventive strategy against excessive fatigue and injury. In the same study, Fousekis et al.<sup>6</sup> indicated that less experienced athletes had higher prevalence of force asymmetries, probably due to their reduced capacity to deal with pre-existing asymmetries from the incomplete development of neuromuscular pattern<sup>6</sup>.

It has been reported that for the ankle, muscle imbalance between invertor and eversor torque can be a risk factor for injuries in this joint<sup>20-22</sup>. Sprains are the most reported due to inversion ankle, affecting the lateral ligaments of the knee joint<sup>22</sup>, and functional ratio values near 1.0 seem to be a pattern to the ankle joint, regardless of physical activity performed<sup>23</sup>. In prospective study investigating ankle injury risk factors, it was identified that functional ratio smaller than 1.0 would be an important indicator of ankle sprain<sup>22</sup>. However, it is essential to observe that the eccentric PT of invertors muscles must present values above the concentric PT of eversors, since studies report that the weakness of invertors muscles makes the ankle chronically unstable<sup>24,25</sup> and therefore susceptible to injuries.

The second aim of this study was to analyze the torque variables according to the position of soccer players in the match. Based on results, it was observed that defenders had eccentric PT values of knee extensors higher than midfielders, not differing from forwarders. These results can

be justified due to the performance of similar specific actions between defenders and forwarders, mainly composed of short and intense movements like sprints and jumps, demanding great effort of knee extensors<sup>9</sup>. Another point to be considered is that the technical training of defenders and forwarders is also similar, but midfielders are submitted to more specific training routine and with more prolonged actions<sup>9</sup>.

Conventional and functional ratios showed no differences among position of players in the match. Defenders have balance of both muscle groups near the ideal considered in literature ( $PTF_{CON}/PTE_{CON} = 0.60 - 0.70$ ;  $PTF_{EXC}/PTE_{CON} \geq 1.0$ )<sup>10,16</sup>. Midfielders and forwarders have conventional ratio values for knee close to ideal, 0.69 and 0.64, respectively, but the functional ratio values are within standards for these muscle groups<sup>9</sup>. These findings can be justified because the eccentric PT values of knee flexors are lower than the concentric PT values of knee extensors. These values are close to those found in other studies<sup>8,17,19</sup>; thus, for these athletes, training aimed at increasing eccentric force capacity of flexors would be relevant, as it would promote an increase in functional knee ratio, which could promote a reduction in this injury risk factor. An interesting point was highlighted by Crosier et al.<sup>9</sup>, who found that soccer players with functional ratio higher than 1.4 had never suffered hamstring injury. These findings show the importance of functional ratio values greater than 1, because this way, hamstrings would be better able to withstand the powerful actions of eccentric contraction in times of high-intensity leg displacement<sup>9</sup>. During a soccer match, a decrease in eccentric PT of hamstrings resulting from fatigue was observed, which could decrease this ratio, especially at the final moments of the match<sup>7,26</sup>. To the ankle joint, values observed were close to 1. Thus, it is suggested that these values could be a balancing standard for athletes with no history of instability or injury in the ankle joint<sup>23</sup>.

## CONCLUSION

We concluded that soccer players analyzed in this study showed no bilateral asymmetries in knee flexor / extensor as well as in ankle invertor / evertor muscles. Analyzing the variables among players of different positions, we concluded that defenders have higher eccentric torque in knee extensors compared to midfielders, with no difference from forwarders. Finally, further studies should be carried out with a larger sample size in order to identify a profile of muscular asymmetry in soccer players of different ages, verifying possible adjustments according to training specificity.

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