

Effects of positions in the isokinetic assessment of knee flexors and extensors of professional soccer players

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Abstract

The present study aims to verify the isokinetic assessment of knee extension and flexion in soccer players, comparing the performance between soccer positions. The sample comprised 136 professional soccer players from five cities belonging to Brazil's first division during the competitive season. Participants separated by player positions – Strikers (S=29, height: 178.9±6.3cm, weight: 78.2±11.1kg) Wingers (W=10, height: 173.7±4.7cm, weight: 71.3±7.4kg), Midfield (M=50, height: 177±5.9cm, weight: 74.5±8.8kg), Goalkeeper (G=14, height: 189.9±4.9cm, weight: 88.4±5.8kg), and Defenders (D=21, height: 186.8±3.5cm, weight: 83.1±6.8kg). The following variables were determined: left anterior peak torque (quadriceps) (LQPT); right anterior peak torque (quadriceps) (RQPT); left posterior peak torque (hamstrings) (LPPT); right posterior peak torque (hamstrings) (RPPT); right quadricep/ right hamstring ratio (RQUADS/RHAMS, using percentage) and left quadricep/ left hamstring ratio (LQUADS/LHAMS, using percentage) and the respective side-to-side comparisons (Deficit = Right – Left peak torque). The equipment used to perform isokinetic tests was a dynamometer by Biodex System 4[®]. Peak torque, maximum repetitions, the energy used during this work, energy used in total isokinetic assessment work, and anaerobic work capacity (W) used in total isokinetic evaluation work were compared by ANOVA One-way and Bonferroni; comparisons considered $p \leq 0.05$. The results showed a significant difference between goalkeepers and defenders > wingers and midfield in peak torque, maximal repetition, total work, and anaerobic work capacity of left anterior peak torque, left posterior peak torque, and right posterior peak torque. Such information may be valuable for more efficient monitoring of muscle strength profiles, improving the application of athletes' training, and identifying risk factors for injury.

Keywords: sports injury, biomechanics, kinetics, muscle strength, motor control, training.

Introduction

Muscle injuries are among the most frequent in soccer players and result from multifactorial origins (Ko et al., 2017; Oliveira et al., 2021; Slimani et al., 2019). It is well known that the magnitude of muscle damage and the other psychological (Esteves et al., 2020; 2021) and physiological alterations (Slimani et al., 2019; Freire et al., 2022) produced by matches are related to oscillations in Creatine kinase stages (Freire et al., 2020), running behaviors (Freire et al., 2020a), as muscular asymmetries (Milanović et al., 2020; Enes et al., 2021; Strauss et al., 2019) and fatigue (Bengtsson et al., 2018). In soccer matches, it has been found that there are differences in external load depending on the playing position. (Freire et al., 2021; Goncalves et al., 2021).

Therefore, soccer matches can affect the players differently depending on their playing positions (Abbott et al., 2018). In the literature, specific factors have been found in relation to physical condition that are associated with an increased risk of lower limb injuries such as a reduced aerobic capacity and a higher fatigue index concerning anaerobic exercise capacity (Freire et al., 2020a; Freire et al., 2021; Ko et al., 2017;). By example, a study found that injured subjects had greater aerobic capacity and greater inter-member asymmetry in the unilateral countermovement jump when compared to their uninjured counterparts (Fort-Vanmeerhaeghe et al., 2022). In this regard, a study analyzed a peak and mean power outputs from soccer players were observed in a 30s anaerobic cycle ergometer test and associated with the isokinetic peak torque outputs for knee flexion and extension (Ko et al., 2017). Also, the external load how the sprinting load was positively related to knee strength

asymmetries (Clemente et al., 2019). Acceleration sum was largely and positively connected with variations in $\dot{V}O_{2\max}$ and peak torque in the hamstrings (Clemente et al., 2019). Besides, dose-response relationships using external load variables were identified in professional soccer players (Clemente et al., 2019). Therefore, positional differences could increase the differences in strength between positions as well as generate more asymmetries (between limbs) and muscular imbalances (quadriceps/hamstring ratio). However, evidence about the influence of player positions on peak power outputs and isokinetic assessments of knee extension and flexion of many soccer players is little (Śliwowski et al., 2017; Tourny-Chollet et al., 2000; Yılmaz et al., 2018), but have used different types of evaluations (angular velocities) as well as different classifications of playing positions.

Preceding reports have indicated differences evaluated in hamstring-to-quadricep peak torque ratios using an isokinetic dynamometer at different angular velocities between men and women who participate in judo, handball, and soccer (dos Santos Andrade et al., 2012; Ayala et al., 2012). With a 66% peak torque ratio, male soccer athletes had significantly higher values than judo competitors, with a 57% hamstring-to-quadricep peak torque ratio. This finding suggests that sport modality and angular velocity influence male athletes' isokinetic strength profiles (dos Santos Andrade et al., 2012). Some authors indicated that side-to-side strength differences are often used in decision-making for a player returning to play soccer after a hamstring injury (Van Dyk et al., 2019). In relation to soccer, the concentric hamstring-quadriceps ratio assessed at 60°/s has been found to be a risk factor for hamstring and quadriceps injury (Lee et al., 2018) in fact a recent systematic review recommends assessing at this speed (Ramos et al., 2022). Therefore, the present study aims to verify the isokinetic assessment of knee extension and flexion in soccer players by comparing the performance of isokinetic strength between soccer positions. We hypothesize that the game position will be a factor interfering with the performance of isokinetic strength.

Method

Participants

The sample was composed of 136 professional soccer players from five different cities belonging to Brazil's first division during the competitive season. Participants were separated by player positions – Strikers (S=29, height: 178.9±6.3cm, weight: 78.2±11.1kg) Wingers (W=10, height: 173.7±4.7cm, weight: 71.3±7.4kg), Midfield (M=50, height: 177±5.9cm, weight: 74.5±8.8kg), Goalkeeper (G=14, height: 189.9±4.9cm, weight: 88.4±5.8kg), and Defenders (D=21, height: 186.8±3.5cm, weight: 83.1±6.8kg). These performances were from professional athletes who competed in national and international representative championships once per week and were regularly training (technical and tactical) 4-7 times a week during the evaluation period. All measures occurred between October and December 2019.

Inclusion criteria: We included complete data of players from the Brazilian League (1st division), which showed all the results in each of the tests used in the present study, aged over 18 years, having no cognitive alterations, no recent surgeries, and no injuries, and having more than two years in the professional soccer level. Exclusion criteria: players who were unable to complete the tests or had limitations during the study, mainly for health reasons, duly certified by doctors. The participants were also instructed not to intake alcohol or drugs for at least 24 hours before the games and measures and were maintaining normal diets.

Before proceeding with data collection, all participants attended a briefing meeting and signed an informed consent document to ensure their understanding of the testing parameters and the risks and benefits of the study. Also, a letter of consent was sent and duly signed by the soccer clubs. This study was submitted to and approved by the Local Committee of Ethics in Research (protocol 051979/2017), following the National Health Council's rules of resolution and according to the WMA Declaration of Helsinki.

Measures

The quadriceps (QUADS) and hamstring (HAMS) torques were gravity corrected during the test, and the dynamometer calibration was made accordingly with the manufacturer's instructions and preceding reports (Hannon et al., 2019; Struzik et al., 2018). Both legs were evaluated in a random order after verbal and visual instruction and feedback. After familiarization with the isokinetic movement (non-recorded two trials for each player), the players were tested over five repetitions of concentric knee extensions and flexions at 60°/s (Ibis et al., 2018).

The time of recovery between each repetition was 1 min (Chaouachi et al., 2011). Isokinetic strength ratios were calculated from measurements of the maximal QUADS and HAMS peak torques. The following variables were determined: left anterior peak torque (quadriceps) (LQPT); right anterior peak torque (quadriceps) (RQPT); left posterior peak torque (hamstrings) (LPPT); right posterior peak torque (hamstrings) (RPPT); right quadricep/right hamstring ratio (RQUADS/RHAMS, using percentage) and left quadricep/left hamstring ratio (LQUADS/LHAMS, using percentage) and the respective side-to-side comparisons (Deficit = Right – Left peak torque) (Van Dyk et al., 2019). At the end of the evaluation, only one of the series performed was chosen, with the highest peak torque value being used (Yapici et al., 2016). Absolute values and the ratio between the right and left side (delta) were observed using Newton-meter (N-m) for analysis (Byrd et al., 2021).

Right Maximal Repetition on Anterior (quadriceps) Total Work (RMRATW), Right Maximal Repetition on Posterior (hamstrings) Total Work (RMRPTW), Left Maximal Repetition on Anterior (quadriceps) Total Work (LMRATW), Left Maximal Repetition on Posterior (hamstrings) Total Work (LMRPTW), Right Anterior (quadriceps) Total Work (RATW), Left Anterior (quadriceps) Total Work (LATW), Right Posterior (hamstrings) Total Work (RPTW), Left Posterior (hamstrings) Total Work (LPTW) of the quantity of muscular work from all repetitions and velocity were observed, with absolute values in Joule (J) (Byrd et al., 2021). The Right Anterior Anaerobic Work Capacity (RAAWC), Right Posterior Anaerobic Work Capacity (RPAWC), Left Anterior Anaerobic Work Capacity (LAAWC), Left Posterior Anaerobic Work Capacity (LPAWC) were measured using the mean of peak power during the test, and the absolute values of anaerobic capacity (Watts – W) were used for analysis (Byrd et al., 2021; Yapici et al., 2016).

Procedures

The tests were carried out at the Soccer Physiology Laboratory of the Rio de Janeiro Football Athletes Union (SAFERJ). The procedures and measures were performed in a room with a stable temperature (21°C) and relative humidity (50%) between 6:00 and 7:00 P.M., and only two soccer players were tested per time (Wyse, Mercer, & Gleeson, 1994). After a 5-min walking warm-up on a treadmill (CTBEX 625T, BRA), a warm-up at a moderate intensity (6 km/h) and mobility exercises focused on lower-limbs, isokinetic strength tests were then performed using a Biodex isokinetic dynamometer (System 4 ProTM, United States) (dos Santos Andrade et al., 2012).

The players were positioned on the isokinetic dynamometer with their motor axis visually aligned with the knee joint axis and with appropriate stabilizations at the trunk, pelvic waist, and thigh levels (de Paula Lima et al., 2019). These adjustments were made to avoid compensating the body for testing efforts by other muscle groups and levers so that the tested knee moves with a single degree of freedom. The lever arm on the lower limb test was placed 3 cm above the tibial malleolus (de Mendonça et al., 2017). The weight of the limb being tested was also determined through the regulation of the isokinetic apparatus system, which seeks to correct the peak torque values in the knee flexion and extension movements due to the action of gravity (Hannon et al., 2019). All the players' alignments and positions at the time of the test were performed according to the instruction manual of the Biodex System 4® (Biodex Medical Systems, USA) (Biodex, 1998). Even before the test was realized, the athletes performed a specific familiarization on the dynamometer to become more familiar with the equipment and all the procedures (de Paula Lima et al., 2019). They were also instructed to perform the test with their hands holding the test chair supports (de Paula Lima et al., 2019). Verbal encouragement was given when the players performed the test repetitions and visual feedback of the recorded torque (Szulc et al., 2017).

Statistical Analysis

Descriptive data for dependent variables and comparisons between positions were performed using the Statistical Package for Social Sciences (SPSS) 20.0 Program. For descriptive statistics, means and standard deviations (SD) of the variables were performed, and all variables were considered parametric according to the Kolmogorov-Smirnov normality test. Comparisons of the variables in the isokinetic test were performed using a one-way ANOVA to verify the differences between groups of positions. A Bonferroni post hoc test was performed when the analysis of variance found a significant difference. The effect size was calculated by Partial eta squared (Pn2) for all tests. The significance level was $p \leq 0.05$.

Results

Table 1 shows the isokinetic strength from measurements of the maximal QUADS and HAMS peak torques.

Table 1: Descriptive analysis of PT comparing professional soccer positions.

Variables	Strikers		Goalkeeper		Right-wingers		Left-wingers		Midfields		Defenders	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RQPT	51.1	281	28.5	217	37.3 ^{#*}	231	36.6	247	51.1	268	47.7	3.7
LQPT	48.9	284	34.2	225	32.5 [#]	233	28.3	246	45.6 [#]	259	35.4	3.3
RQPT/LQPT	14.7	-1.93	11.5	-1.83	12.3	2.9	8.54	-0.26	9.57	1.14	14.3	0.4
RPPT	30.5	189	16.4	144	32.5 [#]	153	22.8 [#]	158	30.5 [#]	173	19.4	5.3
LPPT	24.6	182	21.6	148	23.9 [#]	158	28.7	159	29.9 [#]	171	20.0	3.1
RPPT/LPPT	9.41	-2.21	9.2	-0.3	15.9	5.6	6.13	1.28	9.92	0.4	11.9	1.4
0.18 sec. RQPT	34.2	107	47.0	88.3	23.1	81.7	41.4	84.3	37.5	85.5	45.6	0.9
0.18 sec. LQPT	36.4	106	58.6	74.8	34.6	72.0	41.4	80.3	43.8	93.1	43.8	1.3
0.18 sec. RPPT	36.9	155	36.1	127	34.6	116	60.9	127	47.3	127	53.5	1.9
0.18 sec.	45.5	148	49.3	119	36.4	118	49.6	125	51.3	133	51.8	0.7

Note: M = mean; SD = standard deviation; left anterior peak torque (quadriceps) = LQPT; right anterior peak torque (quadriceps) = RQPT; left posterior peak torque (hamstrings) = LPPT; right posterior peak torque (hamstrings) = RPPT; Torque measured in Newton-meter (Nm); # = significantly different from goalkeepers; * = significantly different from defenders; $p \leq 0.05$.

Statistical analysis indicated significant differences between groups in RQPT comparisons ($F=3.73$, $p=0.003$, $Pn2=0.13$). Goalkeepers showed significance with higher RQPT than right-wingers ($p=0.010$), while the right-wingers showed lower RQPT than defenders ($p=0.046$). The analysis demonstrated differences between groups in LQPT comparisons ($F=3.33$, $p=0.007$, $Pn2=0.12$). The goalkeeper's group showed higher values than wingers ($p=0.007$) and midfielders ($p=0.048$) for LQPT. Comparisons showed effects between groups in the RPPT variable ($F=5.31$, $p\leq 0.001$, $Pn2=0.17$). RPPT was also higher in goalkeepers compared to right-wingers ($p=0.001$), left-wingers ($p=0.028$), and midfield players ($p=0.004$). The statistical analysis also revealed a difference between groups in LPPT ($F=3.05$, $p=0.012$, $Pn2=0.11$), where the goalkeeper and the right-wingers when comparing LPPT ($p=0.11$). The large effect size was seen at 0.18 sec. Goalkeepers showed higher values than midfield players ($p=0.033$) for LPPT. Table 2 shows the maximal repetition of total work analysis with absolute values in Joule (J).

Table 2: Descriptive results of the exercise test regarding the number of maximum repetitions and the energy used during this work.

Variables	Strikers		Goalkeeper		Right-wingers		Left-wingers		Midfields		Defenders	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RMRATW	201	37.8 [#]	241	35.6	184	29.5 [#]	188	43.3 [#]	203	42.4 [#]	219	37.4
LMRATW	212	41.8	248	41.4	182	22.8 [#]	191	31.6 [#]	205	40.2 [#]	220	30.4
RMRPTW	178	29.3 [*]	198	22.0	136	28.6 ^{#*}	158	26.4 [#]	159	32.3 [#]	171	26.7
LMRPTW	165	26.7	189	26.9	148	24.7 [#]	157	29.6	162	28.7 [#]	171	27.3

Note: M = mean; SD = standard deviation; Right Maximal Repetition on previous (quadriceps) Total Work (RMRATW), Right Maximal Repetition on Posterior (hamstrings) Total Work (RMRPTW), Left Maximal Repetition on previous (quadriceps) Total Work (LMRATW), Left Maximal Repetition on Posterior (hamstrings) Total Work (LMRPTW); Energy in joule (J); [#] = significantly different from goalkeepers; ^{*} = significantly different from defenders; all comparisons considered $p\leq 0.05$.

Statistical analysis indicated significant differences between groups in RMRATW comparisons ($F=3.56$, $p=0.005$, $Pn2=0.12$). The goalkeepers showed higher values of RMRATW when compared to strikers ($p=0.031$), right-wingers ($p=0.004$), left-wingers ($p=0.02$), and midfield players ($p=0.021$). The analysis presented effects between groups in the LMRATW variable ($F=4.36$, $p\leq 0.001$, $Pn2=0.14$). When comparing the LMRATW values, goalkeepers showed higher values than the right-wingers ($p\leq 0.001$), left-wingers ($p=0.005$), and midfield players ($p=0.003$).

The analysis also showed a difference between groups in RMRPTW ($F=6.93$, $p\leq 0.001$, $Pn2=0.21$), where the goalkeepers also showed higher RMRPTW values when compared to the right-wingers ($p\leq 0.001$), left-wingers ($p=0.020$), and midfield players ($p\leq 0.001$), while right-wingers had less energy used in the total repetitions than defenders ($p=0.018$).

The analysis confirmed the effects of groups in the LMRPTW ($F=2.02$, $p\leq 0.08$, $Pn2=0.072$). Goalkeepers had higher LMRPTW values than right-wingers ($p=0.005$) and midfield players ($p=0.023$). Table 3 shows Total Work (J) values in the muscular effort during the test, separated by player position.

Table 3: Descriptive results of energy used in total isokinetic assessment work, separated by player position.

Variables	Strikers		Goalkeeper		Right-wingers		Left-wingers		Midfields		Defenders	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RATW	953	183	1111	106	862	122 [#]	880	201	939	207	1037	189
LATW	1000	197	1128	111	862	113 [#]	926	160	942	191 [#]	1036	154
RPTW	841	140	892	69.3	639	138 ^{#@}	748	127 [#]	736	154 ^{#@}	820	130
LPTW	756	186	863	84.5 [*]	701	117	747	146	753	148	801	136

Note: M = mean; SD = standard deviation; Right Anterior (quadriceps) Total Work (RATW), Left Anterior (quadriceps) Total Work (LATW), Right Posterior (hamstrings) Total Work (RPTW), Left Posterior (hamstrings) Total Work (LPTW); [#] = significantly different from goalkeepers; ^{*} = significantly different from defenders; [@] = significantly different from attacker; $p\leq 0.05$.

Comparisons demonstrated significant differences in RATW comparisons ($F=4.04$, $p=0.002$, $Pn2=0.14$). The goalkeepers showed a greater RATW than the right-wingers ($p=0.019$).

The statistical analysis also revealed a difference in LATW ($F=5.21$, $p\leq 0.001$, $Pn2=0.17$), where the goalkeepers had higher LATW rates when compared to defenders ($p=0.002$) and midfield players ($p=0.008$).

Regarding RPTW, the analysis indicated effects between groups ($F=7.71$, $p\leq 0.001$, $Pn2=0.23$). Goalkeepers showed higher values than right-wingers ($p=0.001$), left-wingers ($p=0.004$), and midfielders ($p=0.004$). Besides, forwards show greater RPTW than defenders ($p=0.001$) and midfielders ($p=0.023$). Goalkeepers showed higher LPTW values than defenders ($F=3.43$, $p=0.006$, $Pn2=0.12$).

Table 4 shows the anaerobic capacity during the isokinetic evaluation and the QUADS/HAMS ratios, comparing player positions.

Table 4: Descriptive results of average power (W) used in total isokinetic evaluation work, separated by player position.

Variables	Strikers		Goalkeeper		Right-wingers		Left-wingers		Midfields		Defenders	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RAAWC	144	31.5 [#]	175	22.1	132	20.2 ^{#*}	137	25.6 [#]	147	31.1	166	44.0
LAAWC	152	35.1	176	21.4	132	21.2 [#]	142	21.8	145	30.9 [#]	160	27.4
RAAWC	-2.17	14.8	-0.3	13.3	0.0	10.0	3.0	10.6	-3.14	10.5	-0.43	18.6
LAAWC	124	24.5	138	19.5	97.3	23.2 ^{#*} @	114	20.4	110	24.7 [#]	125	20.9
RPAWC	113	22.4 [#]	136	23.4	105	19.5 [#]	115	21.8	110	23.5 [#]	121	20.9
LPAWC	6.1	11.6	1.7	11.9	-1.33	16.7	2.0	6.9	0.32	13.2	2.1	14.6
RQUADS/RHAMS	71.7	9.3	67.8	6.1	66.2	10.9	67.4	7.3	64.9	10.0	66.4	11.9
RQUADS/RHAMS	63.7	5.4	64.7	8.6	64.5	9.5	67.0	8.7	65.1	8.5	66.4	7.9

Note: Pot = power; M = mean; SD = standard deviation; Right Anterior Anaerobic Work Capacity (RAAWC), Right Posterior Anaerobic Work Capacity (RPAWC), Left Anterior Anaerobic Work Capacity (LAAWC), Left Posterior Anaerobic Work Capacity (LPAWC) were measured using the mean of peak power during the test, and the absolute values of anaerobic capacity (Watts – W) were used for analysis; right quadricep/right hamstring ratio (RQUADS/RHAMS, using percentage) and left quadricep/left hamstring ratio (RQUADS/RHAMS, using percentage); @ = significantly different from attacker; * = significantly different from defenders; all comparisons considered $p \leq 0.05$.

Comparisons presented effects between groups in the RAAWC analysis ($F=4.32$, $p \leq 0.001$, $Pn2=0.14$). The goalkeepers showed greater RAAWC when compared to the right and left-wingers ($p=0.010$) and strikers ($p=0.04$), while defenders showed greater RAAWC than right-wingers ($p=0.048$). The analysis demonstrated significant effects between groups in the LAAWC ($F=4.07$, $p=0.002$, $Pn2=0.14$). LAAWC was also higher in goalkeepers than right-wingers ($p=0.003$) and midfielders ($p=0.011$). Comparisons showed effects in the RPAWC ($F=3.65$, $p=0.004$, $Pn2=0.13$). Goalkeepers showed higher RPAWC when compared to right-wingers ($p \leq 0.001$) and midfield players ($p \leq 0.001$), while right-wingers also showed lower values than strikers ($p=0.015$) and defenders ($p=0.018$).

Discussion

This study aimed to compare isokinetic assessments of knee extension and flexion between player positions. The main results indicated a significant difference between goalkeepers and field players, mainly wingers and midfield players, in peak torque and anaerobic capacity during the extension and flexion of the right and left knee, in the maximum repetitions and total work energies. Strikers showed more hamstring total work on the flexion of the right knee than wingers and midfield players. Besides, forwards also showed a more significant difference between agonists and antagonists on the left side than midfielders and defenders. Defenders showed more excellent averages for lateral power in the left and right knee flexion. The right-wingers showed lower peak torque values and less energy used in the quadriceps maximum repetitions total work of the knee extension than defenders.

Regarding the right quadriceps/right hamstrings ratio, attackers showed a more significant difference than midfielders, while attackers showed less asymmetry than midfielders and defenders in the left quadriceps/left hamstrings ratio analysis. The potential use of a normative database by player position can predict the risk of injury. Hamstring injuries are ordinary and associated with significant morbidity and missed soccer training time, which requires speed and explosive efforts, and the present findings indicate that attackers had a large effect size in the asymmetry of the dominant leg side than other player positions (Elliott et al., 2011; Van Dyk et al., 2019).

There are limitations in connecting the isokinetic muscle strength, measured mechanically, to the possibility of injury; some authors have indicated that an isokinetic muscle strength ratio of $\leq 60\%$ at low angular speed increased the risk of injury (Kim & Jeoung 2016), while other findings reported that increased quadriceps strength from training could reduce activation of antagonistic muscles of the hamstrings (Ayala et al., 2012). Such a low isokinetic balance ratio could cause an increased risk of knee injury by exerting tensional stress on the anterior cruciate ligament due to a decrease in joint stabilizing muscle strength (Cheung, Smith, & Wong 2012). According to player positions, these findings are essential for practical applications with protection against muscle strain provided from strong muscles, appropriate timing, and magnitude of neural control training (Elliott et al., 2011).

Large effect sizes were observed in the total work maximal repetition, and this significance could be explained by the fact that high-level goalkeepers require fast quantitative improvement in the angular torque and angle for which maximum muscle strength is established, as these parameters enable superior execution of actions during which maximum muscle strength requests are generated quickly (Kim & Jeoung 2016). Thus, the

maximum force generated depends on the number and mainly the type of muscle fibers recruited (Wakeling et al., 2012), as well as on the speed and cooperation of nerve impulses; the present results suggest that goalkeepers demonstrated high values of total work and consequently fast recruitment of the nerve-muscle unit, which is essential for increasing the test efficiency, and this was reported to be positively associated with the angle at which maximum muscle strength is revealed (Kim & Jeoung 2016).

The present findings agree with (Tourny-Chollet et al., 2000) when comparing the bilateral strength (Table 1). No significant difference was observed in side-to-side comparisons, except for the hamstring strengths in a concentric mode at 0.18-sec speed, with higher values for goalkeepers. About 78% of the sample had their right leg as the dominant side; this fact is associated with the fact that right leg strength was equal or higher than those of the non-dominant leg during the analysis at 0.18-sec speed, while the ECC. 30 deg/s analysis demonstrated a negative relationship between right and left quadriceps peak power ratios, without significant differences between player positions.

Goalkeepers and defenders showed higher anaerobic capacity, total work, and quadriceps peak power than line positions. In agreement, preceding reports have indicated that defenders demonstrated higher peak power of extensor muscles than midfielders (Konrad & Tilp 2018). Defenders have to move faster during the game to prevent attacks by the opponent, and goalkeepers and defenders have more developed fast-twitch muscle fibril structures due to their sudden reactions at the moment of defense (Konrad & Tilp 2018; Martín-García et al., 2020). In agreement with this, some authors found that goalkeepers and defenders had greater quadriceps strength than forwards (Martín-García et al., 2020). The findings also indicated that goalkeepers' quadriceps strength was more significant than all other line positions when lower-extremity strength ratios were observed (Ruas et al., 2015). Therefore, these findings could be associated with the performance of similar specific actions between defenders and goalkeepers, mainly composed of short and intense actions (i.e., power kicks and jumps) demanding great anaerobic effort of knee extensors.

Regarding the limitations of the present study, it is well documented that the isokinetic dynamometer assessment does not reflect the soccer performance (Ayala et al., 2012; Clemente et al., 2019; de Paula Lima et al., 2019). However, it is a useful tool for a controlled evaluation of strength, and this test has been used to identify strength imbalances in soccer athletes and to consider respective player positions. To the authors' knowledge, the present study is the first to test an isokinetic protocol demonstrating peak power, total work, anaerobic capacity, and strength imbalances of professional Brazilian soccer players. Future studies would look for the development of specific isokinetic screening protocols for soccer players and the development of prevention strategies for hamstring injuries through prospective studies.

Conclusion

The main results showed a significant difference between the game positions for peak torque, anaerobic capacity, maximum repetitions in total work, and total work energy, especially for goalkeepers, defenders, and midfield players. Attackers showed more significant asymmetries in the antagonist and agonist ratio between the right and left sides than other categories. These results suggest that athletes' positions within the game can influence the performance profile of isokinetic strength, justified by the specific functions and activities developed by these players in training and games. This information is essential since the data obtained with the isokinetic evaluation can efficiently monitor the muscular strength profiles, being an essential factor in preventing injuries, rehabilitation of athletes, and performance improvement. It is also considered to advance concerning the specificity of training for players of different positions, improving the application of strength, power, and endurance training according to the greatest need for each player, thus preparing athletes in a more individualized way according to the most significant demand of the game for its specific functions.

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