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HQ RATIO ANALYSIS AS A FUNCTION OF THE TIME SERIES TO IDENTIFY POSSIBLE IMBALANCE THROUGHOUT THE KNEE FLEXION/EXTENSION CYCLE.

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INTRODUCTION

The risk of injuries increases in activities that require change of direction and cutting maneuvers combined with deceleration, and futsal is characterized by this type of action [1]. Indeed, specific levels of imbalance between the hamstrings and quadriceps have been extensively reported as increasing the risk of knee injury [2,3,4]. The hamstrings/quadriceps peak torque ratio (HQ peak torque ratio) is an index used to evaluate the stabilizing efficiency of knee muscles. However, as the torque output is not constant throughout the range of motion, the analysis of ratio throughout the entire motion cycle becomes essential to assess how muscles are controlling forces to stabilize the knee during the motion and prevent the rupture of ligaments. The aim of this study was to characterize the hamstrings and quadriceps torque and HQ ratio to identify possible imbalances throughout the entire knee flexion/extension cycle.

METHODS

We analyzed the performance of the best trial of 19 amateur female futsal athletes aged 20 ± 2.8 years (mean ±SD); body mass of 56.4 ± 6.1 kg and height 1.60 ±0.08 m. A Biodex system-3 was used for the isokinetic testing of knee extension and flexion torque. Each subject performed one set of five knee extension and flexion repetitions at $180°\cdot s^{-1}$ with their dominant limb. This velocity was selected due to relationship between torque produced during knee extension/flexion at this speed and the performance in functional tasks such as jumping and landing [5].

The torque (N•m) generated as function as the whole motion cycle for knee flexion and knee extension was the normalized as function of the motion. The knee flexion at 30° was considered as 0% of the cycle and at 80° was considered as 100%, while knee extension at 80° was considered 0% and at 30° as 100%. The HQ ratio (%) was represented by the hamstring torque value divided by the quadriceps also as function as the motion cycle of the knee for both velocities. The cycle in this case was considered as 80° of knee motion representing 0% and 30° of knee motion as 100%. We compared HQ torque ratio (%) as function of knee angle from 80° to 30° at each 10°, using ANOVA two-way and Tukey post hoc test, adopting $p<0.05$.

RESULTS AND DISCUSSION

Mean quadriceps torque values at $180°\cdot s^{-1}$ were higher at approximately 20% to 60% of the cycle, corresponding to 70° to 50° of knee flexion, corroborating the results found in the literature, in situations isometric [6] and in situations isokinetic [7,8]. Conversely, hamstrings torque was stable throughout the entire motion cycle (Figure 1). The contraction of the quadriceps produces an anterior tibial translation, which is limited by the synergism between the hamstrings and ACL. The constant results found for hamstrings torque, therefore, may be associated with a deficiency in this synergism, overloading the ACL and potentiating injury mechanisms [1].

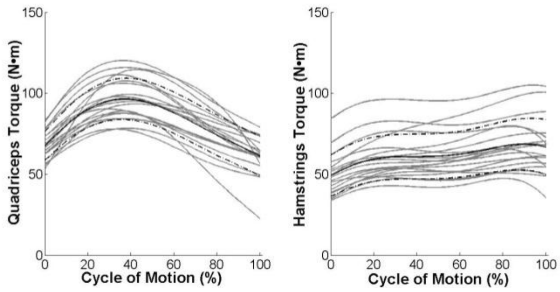

Figure 1: Quadriceps Torque as measured by the cycle of motion from 90° to 0° of knee extension and hamstrings torque by the cycle of motion from 0° to 90° of knee flexion. Gray solid lines represent torque measures of each of the 19 individual players in each situation. Solid and dotted black lines represent group mean and standard deviation, respectively.

Figure 2 shows the HQ ratio varied over the entire cycle, with lower values at the beginning of the cycle (approximately at 20% to 80% of the cycle) and higher values towards the end (approximately at 0% to 20% and 80% to 100% of the cycle). This variation reveals the presence of muscle imbalances at certain amplitudes among these athletes, when using the 60% threshold reference. The high values at the edges of the cycle due to low output torque as a result of the quadriceps force-length relation and the mechanical disadvantage in the full extension of the knee, resulting in dynamic stabilization of the knee part by the hamstrings [8,9]. Some authors examined the relationship between reason and joint range finding high coefficients of determination [7,8]. This shows the importance of verifying the reason throughout the range of motion as a way to analyze the knee joint and muscle function, as performed in this work.

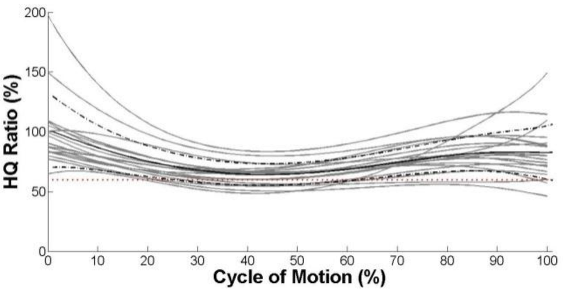

Figure 2: HQ ratio throughout the entire knee flexion/extension cycle at 180°·s^{-1}. Gray solid lines represent HQ ratio measures of each of the 19 individual players in each situation. Solid and dotted black lines represent group mean and standard deviation, respectively. The horizontal dotted line at HQ=60 represents the threshold ratio under which the risk of lesion is increased.

Figure 3 summarizes mean HQ torque ratios at angles of 80° to 30°. The ratio was significantly higher at 30° and significantly less than 70° to 40° of knee motion (30° $p<0.001$). Importantly, values lower than the threshold ratio of 60% was observed from 65° to 50° within the motion cycle. Individually, six athletes showed HQ ratio throughout motion cycle under the threshold of 60%, while with the analysis of HQ ratio using peak torque revealed that only three athletes were under the threshold of ratio. This shows that, in assessing the reason for muscle imbalance from the values of peak torque neglect the force-length relationship, in which different ranges of motion produce different torque values [9,10,11]. With this cannot be identified to changes in dynamic stability among the range of motion that may overload the ACL.

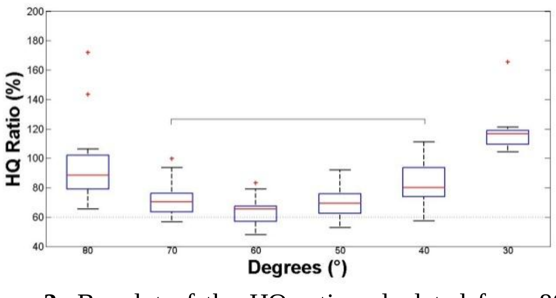

Figure 3: Boxplot of the HQ ratio calculated from 80° to 30° of knee motion, at 180°·s^{-1}. * denotes statistically significant differences at $p<0.01$. The dotted horizontal line represents the threshold ratio under which the risk of lesion is increased.

An enhanced ability to detect specific angles of imbalance may be used to design training plans aimed at strengthening the muscle at specific angles, minimizing the risk of injury and optimizing training and rehabilitation of these athletes.

CONCLUSIONS

The analysis of quadriceps and hamstrings torque values and HQ ratio along the cycle of the motion has been shown to enable the identification of muscle imbalance that would have been otherwise missed by conventional analytical approaches. By determining specific angles of greater tension, the method proposed was shown to be a more sensitive measure of the risk of injury in these athletes. Future studies confirming our findings in other settings and populations may prove useful to enhance the training process, rehabilitation, and injury prevention.

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