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ISOKINETICS TESTING OF THE KNEE IN TWO SOCCER CATEGORIES: DISCRIMINANT ANALYSIS AND TORQUE-ANGLE-VELOCITY RELATIONSHIPS

[1]João Pedro B. Júnior, [1]Monica Angélica C. Silva, [1]Mariana F. Silva, [1]Ligia M. Pereira, [1]Bruno F. Mazuquin, [1,2]Felipe A. Moura, [1]Jefferson R. Cardoso

[1]Laboratory of Biomechanics and Clinical Epidemiology, PAIFIT Research Group, Universidade Estadual de Londrina

[2]Department of Sports Sciences, Universidade Estadual de Londrina

email: paifit.uel@gmail.com

SUMMARY

The aim of this study was to perform knee isokinetic analyzes that discriminated between which variables could belong to the under 17s (U17) soccer category, and which to the professional (PRO) and also to compare 3D strength surfaces between knee muscles. Thirty-four soccer players (n = 17 for each category) participated in this study. The isokinetic variables used for the knee extension-flexion strength analysis were: peak torque (N.m), total work (J), average power (W), angle of peak torque (deg.), agonist/antagonist ratio (%), measured for three velocities (60º/s, 120º/sand 300º/s).Two discriminant analysis were made using the Wilks' Lambda method to identify which variables would discriminate significantly between the two categories. Discriminative variables at 60°/s in the PRO categories were: extension peak torque, flexion total work, extension average power and agonist/antagonist ratio; in the U17 were: extension total work, flexion peak torque and flexion average power. At 300°/s, the variables found in the PRO and U17 respectively were: flexion average power and extension total work. Discriminant variables belonging to the professional category showed the importance of requirements for trivial actions in soccer games such as sprints and ball-striking.

INTRODUCTION

Isokinetic evaluations allow us to identify and quantify torque values, the work and power of muscle groups as well as agonist/antagonist ratios of such groups in order to determine the athletes muscle profile [1,2]. Studies have shown that professional soccer players have a higher isokinetic peak torque than junior athletes of 60º/s and 240º/s [2]. However, few studies have conducted multivariate analyzes in order to discriminate which variables belong to the categories of football together with 3D-angle-torque-velocity assessments. Thus, the aims of this study were to perform knee isokinetic analyzes that discriminated which variables could belong to the soccer category, U17 and PRO and also to compare 3D strength surfaces between knee muscles.

METHODS

Thirty-four soccer players (n = 17 for each category), without a history of lower limb musculoskeletal injury in the three months preceding the study, with regional and national experience, during pre-season, participated in this study. The anthropometric characteristics of the sample were: Age_{PRO} ($\bar{x}$ = 22.9 years, SD = 2.38) Age_{U17} ($\bar{x}$ = 16.3 years, SD = 0.70); BMI_{PRO} ($\bar{x} = 23.9$ kg/m^2, SD = 1.96) BMI_{U17} ($\bar{x} = 22.4$ kg/m^2, SD = 1.88) and right dominance in 16 athletes (94.1%) for the PRO group and 14 (82.4%) for the U17. All the procedures were approved by the Ethical Committee (#055/2012).

The participants attended the Laboratory of Biomechanics and Clinical Epidemiology for a single strength evaluation session. An isokinetic dynamometer (Biodex System 4, Biodex Medical, Shirley, NY) was utilized to measure isokinetic variables of the knee extensor and flexor muscles bilaterally at angular velocities of 60°/s, 120°/s and 300°/s during the concentric contraction module. Prior to the main evaluation, all participants performed a 10-min warm-up on a stationary bike. The participants were positioned seated on the device chair, stabilized by a belt that ran across the trunk and the waist. The hip position was standardized at 100° of flexion (by the positioning of the chair) for all subjects and the lateral epicondyle of the femur was used as the reference point to align the axis rotation of the knee to the rotational axis of the dynamometer. The resistance torque was applied at 5 cm above the medial malleolus. The athletes were instructed to keep their arms crossed in front of their trunk during the test to avoid compensation. Calibration was performed according to the manual provided by the equipment manufacturer and the gravity correction was obtained from the torque exerted by the resistance arm of the equipment on the leg, relaxed at the knee extension position. Flexion-extension range of motion was set at 90° (considering the full knee extension to be 0°).

Before each assessment, isokinetic familiarization contractions were done according to the assessment protocol of the equipment. Next, the participants performed five maximal concentric knee extension-flexion contractions through the pre-stipulated range of motion (0-90 degrees) for each velocity. Verbal encouragement and visual feedback on a computer screen were used in an attempt to encourage the subjects to produce maximum torque during the contractions. The isokinetic variables used for the knee extension-flexion strength analysis were: peak torque (N.m), total work (J), average power (W), angle of peak torque (deg), agonist/antagonist ratio (%), for three velocities (60°/s, 120°/s and 300°/s). All procedures were performed by the same researcher and the order of isokinetic velocity was randomized.

The raw torque data were converted into a txt file from the equipment and filtered in a low pass filter (Butterworth,4th order) with a cutoff frequency of 20 Hz and 12Hz for the 60°/s and 300°/s data, respectively, using a specific algorithm (Matlab ® 7.8.0). For stipulating the three-dimensional torque-velocity-angle surfaces a mathematical model was used, where geodesic distances on a weighted graph were incorporated with metric multidimensional scaling [3].The algorithm estimated the intrinsic geometry of the torque and position data based on a rough estimate of each data neighbor´s points in relation to speed. The 3D surface curve was made from the mean angular velocity, torque and position (angle) curves of the five isokinetic contractions of each subject [4].

The homogeneity assumptions of the covariance matrices from each group were tested by the M Box test. Two discriminant analysis were made with the Wilks' Lambda method to identify which variables (related to the 60°/s and 300°/s velocities) would discriminate significantly between the two groups (PRO or U17 soccer players). The canonical correlation was used to measure the association between the discriminant scores and athlete group. Afterwards, it was used the classification analysis to show how well the cases were fitted into the categories and then, confirmed by cross-validation. Significance was stipulated at 5%.

RESULTS AND DISCUSSION

Variables were divided in relation to 60°/s and 300°/s. There was no difference between dominant and non-dominant lower limbs, so, for the discriminant analysis, the dominant limb was used. Discriminative variables at 60°/s in the PRO categories were: extension peak torque, flexion total work, extension average power and agonist/antagonist ratio; in the U17 they were: extension total work, flexion peak torque and flexion average power (λ = 0.52; $\chi^2_{(9)}$ = 17.7; *P* = 0.03). At 300°/s, the variables found were in the PRO and U17 respectively: flexion average power and extension total work (λ = 0.38; $\chi^2_{(9)}$ = 26.5; *P* = 0.002). The percentage of individuals correctly classified was 79.4 % at 60°/s and 91.2% at 300°/s. However, cross-validation produced correct classifications of 64.7% and 76.5%, respectively.

Torque capability is significantly influenced by dynamic parameters such as the angular velocity [5]. It is known that to study peak torque, lower angular velocities are the best choice [6]. In this study it was found that extension peak torque at 60°/s is a discriminant variable for being a professional athlete. Lehance et al. reported significant differences in the quadriceps concentric peak torque at 60°/s between the PRO and U17 groups [2]. Muscular variables are one of the most important components of physical performance in sport, and the knee extensor muscles play an important role during soccer tasks such as sprinting, jumping and ball-kicking.

3D strength surfaces can provide additional information on human muscle activity as a function of joint angle and contraction velocity that are not available from 2D results. In figure 1, it is possible to note that professionals have, not only higher torque at higher speeds but also superior angles of peak torque when compared with the U17 athletes. Thus normative data throughout the range of dynamic contraction conditions are needed for strength model development and validation of digital human model applications [4].

CONCLUSIONS

The discriminant variables at 60°/s, for PRO, were: extension peak torque, flexion total work, extension average power and agonist/antagonist ratio; for U17 were: extension total work, flexion peak torque and flexion average power. At 300°/s: flexion average power (PRO) and extension total work (U17). Discriminant variables for being in the professional category showed important requirements for trivial actions in soccer games such as sprints and ball-striking, that demand high strength and power. The applications of digital human modeling, torque-velocity-angle relationships for knee joint were proposed for these categories of soccer. Individual analysis and error considerations are needed in future studies.

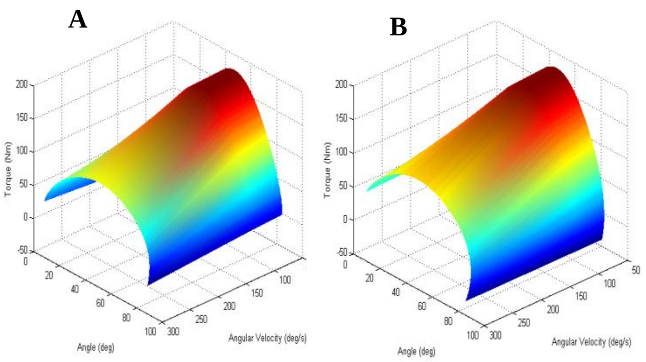

Figure 1: Three-dimensional surfaces (torque × velocity × angle) for the knee extension **-** U17 (A) and PRO (B).

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