Knee extensor strength asymmetry: different metrics, different information?

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Résumé

Introduction : Knee injuries, such as anterior cruciate ligament (ACL) rupture, are frequent in sport and commonly associated with impaired neuromuscular function (Tayfur et al., 2021). Consequently, this function can be assessed through strength capacities during rehabilitation to provide objective criteria which help to prevent reinjuries (Grindem et al., 2016). The deficit in the injured leg is commonly quantified using the Limb Symmetry Index (LSI) of maximal isokinetic (60-300∘/s) and/or isometric strength (Rambaud et al., 2018). However, these traditional assessments, typically measure maximal force at low or zero velocity, after a prolonged contraction and in a non-fatigued state, and so only capture a limited aspect of muscle function. They do not reflect the real-world demands placed on the neuromuscular system which often involve the ability to generate force quickly (explosiveness), at various velocities (force-velocity) or under fatigue (strength-endurance). The extent to which LSIs derived from these alternative strength capacities correlate with those from conventional tests remains unclear. If discrepancies exist, alternative assessments may offer complementary information valuable for return-to-sport decision-making. This study aimed thus to test how much force at low and high velocities, explosiveness and strength-endurance metrics provide different information about neuromuscular function and inter-limb asymmetry of healthy participants.
Method : Different knee extensor strength capacities for both limb were measured on 23 healthy adults. During the first session, participants performed two maximal voluntary contractions, 10 burst-like contractions and a strength-endurance evaluation (RACLET, Bowen et al., 2023). Maximal isometric torque (Tmax), Tmax-normalized rate of torque development (RTD) at 50, 100, 200ms of contraction (RTD50, RTD100, RTD200) and Tmax-normalized critical torque (TC) were computed. In a second session, force-velocity relationship was obtained during maximum intensity isotonic contractions (PRIMUS RS) at six different resistances ranging from 3Nm to the maximum resistance the participant can move. Maximal theoretical torque (T0), velocity (V0) and power (Pmax) were computed. Moreover, participants also performed three maximal knee isokinetic extensions at 60∘/s and five at 240∘/s to measure the maximal torque at 60∘/s (IK60) and 240∘/s (IK240). LSI (%) was determined for each parameter, the reference limb being defined as the leg with the highest Tmax. Two Principal Component Analyses (PCA) followed by a K-means clustering algorithm were performed on both values and LSI of the different strength capacities.

*Intervenant

Results : PCA analyses showed different components (eigenvalue< 1) to explain the variances in strength metrics and LSI with clusters of metrics displaying similar behaviours, uncorrelated to others. For strength capacity values, four clusters were identified. The first cluster ("maximal torque at low velocity") was composed of Tmax, T0, Pmax, IK60 and IK240. The second cluster ("maximal torque at high velocity") was composed of V0. The third cluster ("explosiveness") was composed of RTD50, RTD100 and RTD200. The fourth cluster ("strength-endurance") was composed of TC.

For LSIs of each metrics, three clusters were identified. The first cluster ("maximal strength asymmetry") was composed of LSITmax, LSIPmax, LSIIK60 and LSIIK240. The second cluster ("explosiveness asymmetry") was composed of LSIRTD50, LSIRTD100 and LSIRTD200. The third cluster was less clear and gathered LSIT0, LSIV0, LSITc.

Conclusions : These findings offer practical insights into the multifaceted nature of neuromuscular qualities and their associated inter-limb asymmetries in healthy individuals. They highlight the relevance of assessing diverse strength metrics associated to different qualities such as explosiveness, high-velocity strength, and strength endurance, particularly in the context of injury rehabilitation.

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