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Human foot muscles strength and its association with acceleration sprinting, cutting and jumping performance kinetics in high-level athletes

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INTRODUCTION:
The human foot is composed of intrinsic and extrinsic foot muscles that dissipate and generate net center of mass energy during rapid tasks such as running, jumping or hopping. In addition, it acts also as an efficacious lever during propulsion allowing rapid transfer of ankle plantar flexors forces into the ground. If this energetic and biomechanical role is indisputable, the literature pertaining to the relation between human foot muscles strength and sport performance is not well established. Therefore, the main aim of this study was to understand the relationship between metatarsophalangeal joint (MTPj) flexion strength and sprint acceleration, cutting and jumping performance and kinetics.
METHODS:
In fifty-two high-level athletes (n=5 females, 20.1±2.1yrs, body mass index (BMI) 23.2±3.1) we assessed Foot Posture Index, foot passive stiffness using the Arch Height Index Measurement System and MTPj maximal isometric flexion torque using a custom-built dynamometer with a 6-components force sensor. Ankle plantarflexion and knee extension isometric torque were assessed using an isokinetic dynamometer whereas kinetic variables were assessed during sprinting, 90° cutting, foot-ankle hopping and vertical and horizontal jumping using a 5.4-m force platforms system. Stepwise backward multiple linear regressions were used to understand the relationships between all the aforementioned variables.
RESULTS:
During maximal speed phase we found a significant contribution of MTPj flexion strength and foot passive stiffness to explain effective vertical impulse (adjusted r^2=0.28, p=0.008) and a contribution of MTPj flexion strength and foot-ankle reactive strength to explain contact time (r^2=0.35, p=0.003). Interestingly, the association of ankle plantarflexion isometric torque and foot passive stiffness was significantly associated with propulsive impulse during early acceleration (r^2=0.31, p=0.005) whereas ankle plantarflexion isometric torque and foot-ankle reactive strength were associated with cutting performance (r^2=0.35, p<0.001). No other significant relationships were found between MTPj flexion strength and performance or kinetics in cutting and jumping task.
CONCLUSION:
These findings show the contribution of MTPj flexion strength and foot passive stiffness (28% and 35% of the variance explained, respectively) to effective vertical impulse and contact time when running speed reach its maximal value. Accordingly, the foot might be a factor to consider for sprinting performance due to the importance of a large ground reaction force production over a short contact time at high maximal speed. Finally, ankle plantar flexors strength and foot-ankle reactive strength seem to explain 33% of the variance in cutting performance and propulsion during early acceleration. This study highlights that the foot-ankle strength capability has a greater influence on horizontally-oriented explosive movements than overall vertically-oriented ones.

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