24th Annual ECSS Congress Prague/Czech Republic, July 3-6 2019

Muscle-tendon function in elite high jumpers

Albracht, K.1,3, Goldmann, J.P.1,4, Heinrich, K.1, Sanno, M.1, Stäudle, B.1,3, Ritzdorf, W.2, Brüggemann, G.P.1, Braunstein, B.1,4

German Sport University <1>, IAAF World High Jump Centre <2>, University of Applied Science Aachen <3>, M@mentum <4>

INTRODUCTION
During take-off, the horizontal velocity of the jumper's COM from the run-up must be transformed into vertical velocity (Dapena, 2006). It is assumed, that the optimal run-up velocity depends on each athletes ability to resist buckling of the take-off leg through sufficient muscular strength of the knee extensor muscles (Dapena, 2006). Many studies have demonstrated that the plantar-flexor muscle-tendon units are equally important in producing force and power required for jumping. However, today no information is available about mechanical properties of the plantar-flexor muscle-tendon units of elite high jumpers. To obtain a better understanding of the contribution of the plantar-flexor muscle-tendon units to high-jump performance, we analyzed muscle and tendon properties as well as 3D jump kinetics and kinematics of elite high jumpers.

METHODS
High jumps of seven world-class athletes (personal best 224±6 cm) were captured with 19 infrared-cameras (300 Hz, Vicon, UK). Ground reaction forces of the take-off were recorded with a 3D force-plate. Ankle joint work and power in the sagittal plane were determined with a standard inverse dynamics approach and a full body model (ALASKA, Germany). Additionally, maximal isometric torque for plantar-flexion, fascicle length and tendon length of the gastrocnemius medialis muscle and Achilles tendon stiffness were determined using a combination of dynamometry, ultrasound, and kinematic data.

RESULTS AND DISCUSSION
The average maximum COM height was 2.13 ± 0.05 m with an average run-up velocity of 6.8 ± 0.4 m/s and an average contact time of 185±29 ms. Despite a considerable inter-individual variability of the examined variables, only one significant correlation was found between maximal isometric plantar-flexion torque and run-up velocity ($r=-0.85$, $p=0.01$). This indicates that athletes with a slow run-up velocity have stronger calf muscles relative to body mass. None of the other variables (run-up velocity, energy loss during take-off, net ankle work, peak ankle power) showed a correlation to the properties of the muscle-tendon unit, which could be due to the small number of subjects. However, the analysis of the individual data indicates that jumpers with a fast run-up velocity and a short ground contact have short stiff tendons and long muscle fascicles. These tendon properties are necessary to enable the storage and release of the COMs energy within the constraints of the brief ground contact. The long fascicles, probably enable sufficient force generation at fast shortening velocities during the run-up, which may also explain the negative correlation between muscle strength and run-up velocity. The results of this study indicate that different take-off techniques of elite high jumpers are partly reflected in the triceps surae muscle-tendon properties.

REFERENCES
Dapena J (2006). Scientific services project – High-Jump.

Topic:

Presentation form: Invited