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DIFFERENCES IN ANKLE AND KNEE JOINT KINEMATICS AND KINETICS DURING THE FIRST STANCE PHASE OF THE ACCELERATION PHASE DIFFERENTIATE BETWEEN YOUNG AND ADULT HIGH LEVEL SPRINTERS

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Preferred Presentation: Oral Presentation
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Introduction and Objectives: Sprint running can be divided in several distinct phases including the sprint start, acceleration phase and maximum velocity phase [1]. In the acceleration phase, the first stance phase is a unique element, in which power is transferred from the block phase to the rest of the acceleration phase. To better understand the difference in sprinting performance between adult and youth sprinters, joint power, joint stiffness and individual muscle-tendon complex maximal stretching and shortening velocities at the ankle and knee joint of the stance leg were determined during the first stance phase following a block clearance.

Methods: Eleven adult athletes (6 male and 5 female) and thirteen young athletes (5 male and 8 female) performed an explosive sprint start action. Twelve MX3 cameras (250Hz) and a Kistler force plate (1000 Hz) were used to collect 3D marker coordinates and the ground reaction force (Nexus, Vicon). A musculoskeletal model [2] was scaled to each subject's individual anthropometry using OpenSim 1.9. An inverse kinematics procedure was conducted to obtain joint angles and to derive joint angular velocity and individual muscle-tendon complex lengths of ankle plantar flexor and knee extensor muscles. An inverse dynamics procedure was conducted to calculate the net joint moments and joint power at the ankle, knee and hip. Joint stiffness was defined as the slope of the linear regression line on the moment-angle curve. For each joint this curve was split in two at the maximal moment, joint stiffness was thus calculated for the ascending limb and the descending limb of both the ankle and knee joint. Muscle-tendon complex length changes were normalised to the muscle-tendon complex lengths in a neutral standing position (ankle, knee and hip joint angles were set to 0 deg. for each individually scaled model). Aftwerwards the derivative of these curves, showing the muscle-tendon complex length changes were calculated for maximal stretching and shortening velocities of 7 individual muscle-tendon complexes. All parameters were first tested for skewness, after which a one-way ANOVA was used to determine significant ($p < 0.05$) differences between groups for the non-skew parameters. All data presented in the results section were normally distributed.

Results: Joint power contribution to total power generation (sum of ankle, knee and hip joint power) was significantly different between the youth and adult sprinters. The contribution of the ankle joint was larger ($p = 0.024$) in the youth sprinters (32 ± 10%) compared to the adult sprinters (21 ± 12%). The adult sprinters, on the other hand, had a larger ($p < 0.001$) contribution from the knee joint (34 ± 12%) to total power generation compared to the youth sprinters (12 ± 5%). Knee joint stiffness on the descending limb of the moment-angle curve was larger ($p = 0.005$) in the adult (5.56 Nm/deg. ± 2.18 Nm/deg.) compared to the youth sprinters (3.38 ± 1.18 Nm/deg.). Although maximal stretching velocities were not different between groups, the maximal shortening velocities were larger ($p < 0.045$) in the adult (0.94 ± 0.12 mm/ms; 0.87 ± 0.11 mm/ms; 0.89 ± 0.11 mm/ms for the) compared to the youth sprinters (0.79 ± 0.20 mm/ms; 0.71 ± 0.20 mm/ms; 0.73 ± 0.21 mm/ms) for the m. soleus, m. gastrocnemius medialis and m. gastrocnemius lateralis respectively.

Conclusion: Joint power and joint stiffness results suggest that the faster adult sprinters rely more on the knee joint than on the ankle joint, as opposed to the youth athletes. Although youth sprinters have a larger power generation in the ankle

joint, their plantar flexor muscles are shortening at a lower maximal velocity compared to the adult sprinters. Since the knee but not the ankle joint stiffness was different between our groups and increasing running velocity has been linked with an increased stiffness in the knee and not in the ankle joint [3], it appears that sprint running performance may be more dependent on knee rather than ankle joint stiffness.

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[2] Hamner et al., *J Biomech*., 43:2709–2716. 2010
[3] Kuitunen et al., Med Sci Sports Exerc., 34:166–173. 2002

Disclosure of Interest: None Declared