ANKLE MUSCLE STRENGTH AND ACHILLES TENDON PROPERTIES IN RUNNERS WITH DIFFERENT SPEED DEPENDENT STRIKE PATTERNS

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The purpose of this study was to investigate ankle muscle strength and Achilles tendon anthropometrics of heel-strikers who a) do not switch or b) do switch their strike pattern towards a forefoot-strike when increasing running velocity. Differences were primarily found in the capacity to develop plantarflexion strength. This indicates that the two groups differ - next to kinematic aspects - in muscular characteristics of the plantarflexors, which could be influenced by Achilles tendon properties.

KEY WORDS: Running, strike pattern, muscle, tendon.

INTRODUCTION: Approximately 75 – 95 % of the long-distance runners are heel-strikers. It is unclear why runners predominantly heel-strike at their preferred running speed, but there is evidence that running speed is a key determinant for an individual preferred strike pattern (Breine, Malcolm, Frederick, & De Clercq, 2014). As response to increasing velocity (3 – 6 m/s), recently two types of heel-strikers were identified (Schwameder, Wunsch, Schatz, & Kröll, 2014). The first type representing the majority of heel-strikers (75 %) does not switch the strike pattern with increasing running velocity (Non-Switcher). The second type shows an abrupt switch from heel to forefoot-strike at faster velocities (Switcher).
In general heel- and forefoot-strike differs regarding kinematics, force loading and joint loading pattern. In terms of muscle activation the plantarflexor muscles are activated 11 % earlier and 10 % longer in forefoot running (Ahn, Brayton, Bhatia, & Martin, 2014). Thus, the aim of this study was to compare Switcher and Non-Switcher regarding a) ankle muscle strength and b) anthropometric characteristics of the Achilles tendon (AT), which acts as a force transmitter of the plantarflexors m. gastrocnemius and m. soleus.

METHODS: Eighteen male participants with running experience (age 27 ± 5 yrs, mass 79 ± 9 kg, height 1.82 ± 0.07 m, limb length 0.93 ± 0.06 m, tibia length 0.52 ± 0.03 m, > 5 yrs running experience, 19 ± 7 km/week) were recruited. 11 Non-Switchers and 7 Switchers were classified during a ramp test on a treadmill (start 3 m/s, step 0.1 m/s every 5 s, end 6 m/s) and were controlled during overground running with a 2D video analysis (200 Hz treadmill, 50 Hz overground). The anthropometric variables of the AT in particular AT length (calcaneus to m. gastrocnemius), free AT length (calcaneus to m. soleus) and AT cross-sectional area (CSA) were analyzed via ultrasound (LOGIQ e BT12, General Electric).
Subsequent to a standardized warm-up the participants performed two maximal isometric contractions for plantarflexion and dorsiflexion on a dynamometer (IsoMed 2000). The participants were instructed to perform isometric efforts “as fast and as forceful as possible”. Torque data were filtered using a fourth-order Butterworth filter with a cutoff frequency of 15 Hz and the maximum isometric torque (MVC) of each trial was calculated. The trials showing the highest MVC values were chosen for further analysis. Rate of torque development (RTD) was derived as the average slope of the torque-time curve (Δtorque/Δtime) over the time intervals 0-10, 0-20, …, 0-250 ms relative to the onset of contraction. The maximal rate of rise in toque was defined as RTD_{max} (Oliveira, Oliveira, Rizatto, & Denadai, 2013). Group differences between the two types of runners (Non-Switcher, Switcher) were statistically tested using t-tests ($p < 0.05$). Cohen’s d_z described the relevance of differences.

RESULTS AND DISCUSSION: General anthropometric data (mass, height, limb- and tibia length) revealed no significant differences between Non-Switchers and Switchers.

Differences primarily were observed in the plantarflexion strength (Table 1). Switchers showed a trend towards an increased MVC in plantarflexion (14 %) and displayed significant higher RTD_{max} values. Furthermore, the time-induced changes in RTD (Fig. 1) revealed significant higher values in the late phase of RTD. Whereas the early phase of RTD is influenced by intrinsic muscle contractile properties and neural drive the late phase is primarily determined by factors that promote gains in MVC as muscle CSA, neural drive and stiffness of the tendon-aponeurosis complex (Oliveira et al., 2013). Regarding the anthropometric variables of the AT no changes in AT length and CSA were observed, which is in line with findings from Kubo, Miyazaki, Tanaka, Shimoju, and Tsunoda (2014), who compared habitual heel- and forefoot strikers. The free AT length, however, tends to be longer for Switchers compared to Non-Switchers. It could be speculated that these findings lead to a different AT stiffness in running.

Table 1: Results overview

	Non-Switcher Mean ± SD	Switcher Mean ± SD	Diff Mean ± SD	p-value	d_z
AT CSA [cm²]	0.65 ± 0.14	0.66 ± 0.14	0.01 ± 0.14	0.833	0.10
AT length [cm]	22.4 ± 2.9	22.4 ± 1.5	0.0 ± 2.4	0.975	0.02
Free AT length [cm]	5.5 ± 1.8	7.1 ± 1.9	1.6 ± 1.9	0.103	0.84
MVC Dorsalext [Nm/kg]	0.51 ± 0.10	0.53 ± 0.08	0.02 ± 0.09	0.656	0.22
MVC Plantarflex [Nm/kg]	2.84 ± 0.63	3.30 ± 0.31	0.46 ± 0.53	0.093	0.86
RTD_{max} Dorsalext [Nm/s]	272 ± 78	297 ± 40	25 ± 66	0.447	0.38
RTD_{max} Plantarflex [Nm/s]	1041 ± 228	1289 ± 257	248 ± 239	0.048	1.04

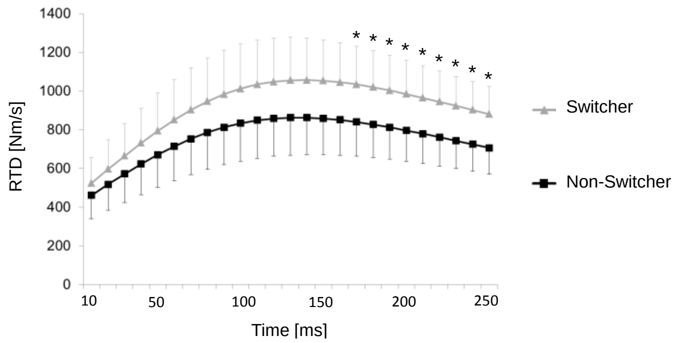

Figure 1: Time-induced changes in RTD for plantarflexion (mean ± SD)

CONCLUSION: Based on the foot kinematics runners can be classified into Non-Switchers and Switchers. This study shows that the two groups differ - next to kinematic changes - regarding the capacity to develop plantarflexor strength. These findings combined with the anthropometric characteristics of the plantarflexor muscle-tendon unit should attribute to a better understanding of the most frequently used strike type in endurance running. Further research, however, is needed to possibly draw conclusions for the running performance or the ethology of running related injuries of Non-Switchers and Switchers.

REFERENCES:

Ahn, A. N., Brayton, C., Bhatia, T., & Martin, P. (2014). Muscle activity and kinematics of forefoot and rearfoot strike runners. *Journal of Sport and Health Science, 3*(2), 102-112.
Breine, B., Malcolm, P., Frederick, E. C., & De Clercq, D. (2014). Relationship between running speed and initial foot contact patterns. *Medicine and Science in Sports and Exercise, 46*(8), 1595-1603.
Kubo, K., Miyazaki, D., Tanaka, S., Shimoju, S., & Tsunoda, N. (2014). Relationship between Achilles tendon properties and foot strike patterns in long-distance runners. *Journal of Sport Science 33*(7), 665–669.
Oliveira, F. B., Oliveira, A. S., Rizatto, G. F., & Denadai, B. S. (2013). Resistance training for explosive and maximal strength: effects on early and late rate of force development. *Journal of Sports Science and Medicine, 12*(3), 402-408.
Schwameder, H., Wunsch, T., Schatz, T., & Kröll, J. (2014). Effect of running speed on the foot-ground angle in heel strikers. In S. Nigg (Ed.), *Int. Calgary Running Symposium*. Calgary - Canada.