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ScienceDirect

Journal of Sport and Health Science 7 (2018) 123–124

www.jshs.org.cn

Commentary

"Excessive muscle strain as the direct cause of injury" should not be generalized to hamstring muscle strain injury in sprinting

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Received 1 May 2017; revised 6 May 2017; accepted 8 May 2017
Available online 19 May 2017

The debate about the mechanisms of hamstring injuries in sprinting in the *Journal of Sport and Health Science* reminded me of the discussion of the force enhancement mechanisms in stretch-shortening cycles (SSCs) 20 years ago in the *Journal of Applied Biomechanics*. The controversies concerning the proposed mechanisms were mainly due to the difference in the levels of observation between animal and human studies.[1,2] An important question debated 20 years ago was "Are the muscle fibers and muscle spindles lengthened during SSCs?" a question that is also important to the current discussion on hamstring strain injuries.

Yu et al.[3] proposed that excessive muscle strain is the direct, if not exclusive, cause of muscle strain injury. However, they ignored the idea that there might be different types of acute hamstring strains: high-speed running type and stretching-type (i.e., kicking) injuries.[4] The animal experiments[5–7] cited by Yu et al. provide the general mechanisms for stretching-type injuries. However, they should not necessarily be generalized to hamstring injuries in sprinting because not all animal studies support the notion that high strains are necessary to cause muscle injuries.

Warren et al.[8] investigated muscle injuries in isolated rat soleus muscles subjected to 5 eccentric contractions. They measured peak eccentric contraction force, stretch magnitude, stretch velocity, and initial muscle length. They observed that immediate muscle injuries were most closely related to the peak force produced during stretching, and injuries at 60-min following the eccentric protocol were most closely related to the initial muscle length. Brooks et al.[9] found that injury immediately following a single stretch was associated with muscle strain and work done during the stretch. Hunter and Faulkner[10] found that the best single predictor of eccentric injury was the final length to which muscle fibers were stretched, and differences in force deficits were best explained by the work during stretching and the initial length.

Thelen et al.[11] reported that the peak hamstring muscle-tendon lengths in sprint running occurred during the late swing phase. Schache et al.[12] reported that the peak hamstring muscle-tendon unit length occurred at an intermediate running speed of 6.9 ± 0.1 m/s. Peak biceps femoris long head strains in pre-injury and injury trials of sprint running were 12.2%[13] and 12.9%.[14] The length of the hamstrings in the upright posture is 88% of the optimal length.[15] Therefore, the maximum hamstring lengths in sprint running are close to the muscle optimal length, which is different than the strains reported in animal studies of eccentric muscle injury[5–7] cited by Yu and colleagues, and they cannot be regarded as excessive. Muscle strain as the primary cause of muscle strain injury is further challenged by the observation that the maximum hamstring strain does not increase when running speed increases from 6.9 to 9.0 m/s,[12] while most hamstring injuries in sprinting occur while sprinting at or close to the maximum speed.[16]

It has been suggested[17–20] that muscle fibers may shorten while the muscle tendon unit is elongating. Unfortunately, there are no experimental studies on fascicle lengths of the hamstring muscles in sprint running, and while theoretical studies suggest a lengthening of the hamstrings in the mid-swing phase,[21,22] these findings cannot be taken as direct evidence of hamstring fascicle lengthening because hamstring slack lengths are not known with certainty.[23] Even if the hamstring fascicles were lengthened in the swing phase of sprint running, the strain would be limited because of the presumed high gear ratio of the pennate hamstring muscles.[24]

In summary, it might not be justified to assume that excessive strain causes hamstring injuries in the late swing phase of sprint running. Muscle strain injuries produced by eccentric actions in animal studies are typically induced by strains beyond the optimal muscle fiber length, while hamstrings injuries in sprint running likely occur near optimal lengths; that is, at relatively short lengths. Studies investigating the fascicle behavior *in vivo*

Peer review under responsibility of Shanghai University of Sport.

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https://doi.org/10.1016/j.jshs.2017.05.006

during sprint running, and studies focusing on injury mechanisms based on injury trials, are needed.

Competing interests

The author declares that he has no competing interests.

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