



Available online at www.sciencedirect.com



Journal of Sport and Health Science 6 (2017) 139-140

Commentary



www.jshs.org.cn

Comments to "Mechanism of hamstring muscle strain injury in sprinting" by Yu et al.

Yu Liu^{a,*}, Yuliang Sun^b, Wenfei Zhu^b, Jiabin Yu^c

^a Key Laboratory of Exercise and Health Sciences of the Ministry of Education, Shanghai University of Sport, Shanghai 200438, China

^b School of Physical Education, Shaanxi Normal University, Xi'an 710119, China ^c Research Academy of Grand Health, Faculty of Sport Science, Ningbo University, Ningbo 315211, China

Research networky of Grand network, nature of Sport Science, Ningoo Chiversny, Ningoo 515211, Chin

Received 8 November 2016; revised 15 November 2016; accepted 23 November 2016

Available online 27 January 2017

We have carefully read Dr. Yu and his colleagues'¹ review on the mechanism of hamstring muscle strain injury in sprinting. There is no doubt that they have done a lot work in this field. Their views are based on 3 pieces of evidence. First, observations from *in situ* animal models suggest that muscle strain injuries are highly associated with eccentric contractions. Second, the magnitude of muscle strain, rather than the force, is the primary risk factor for strain injuries. Third, studies on sprinting biomechanics suggest that the hamstrings undergo the greatest stretch and reach their maximum length during the late swing phase. Therefore, the late swing phase is considered the most hazardous for hamstring injuries to occur.

First and most importantly, we agree that the late swing phase is a phase of high risk for incurring hamstring strain injuries. Our studies are consistent with previous research reporting that the peak hamstring stretch and force occur in the late swing phase of sprinting prior to foot contact.^{2,3} Our results showed that during the terminal swing phase, the thigh starts to extend backward but the leg is still rotating forward due to motion-dependent torque (MDT, or termed as interaction torque).⁴ In order to pull the leg backward and downward prior to ground contact, the hamstring muscles contract intensely, creating an acceleration that causes a quick eccentric to concentric change. Our data revealed that the largest muscle torques (MST) occurred at the end of the swing phase, almost simultaneously with the largest hip extension and knee flexion MST. The MST was used mainly to counterbalance the stretching effect of the MDT during the swing phase. Moreover, our results highlighted that the high load on the hamstrings was caused by the MDT, since the MST functioned to counterbalance the MDT to control the rapid limb rotation during the swing phase. We further found that the major component of the

Peer review under responsibility of Shanghai University of Sport.

* Corresponding author.

E-mail address: yuliu@sus.edu.cn (Y. Liu)

MDT at both knee and hip was the motion-dependent torque due to the acceleration of the leg. These findings help explain why the hamstrings are stretched to their maximum length and the muscle force reached its maximal value in the late swing phase, as observed by others.

Second, there is great debate whether the hamstrings are susceptible to injury during the stance phase of sprinting. Although many scientists reject the idea that the stance phase poses any risk of hamstring injury because it is not associated with an eccentric contraction, some will insist that the hamstrings are most susceptible to injury in early stance.^{5,6} The rationale for this conjecture is that both the knee flexion and hip extension moments reach the greatest value in early stance, with the hamstring muscles generating the main force. The vast majority of force must be absorbed by the muscles in early stance,⁷ which is not surprising when one considers that a human leg is about 10% of the entire body weight, while the ground reaction forces (GRFs) during sprinting are more than 300% of body weight.

Our findings also support this point of view.⁴ During the initial stance phase, the GRFs pass in front of the knee and hip, which results in a large extension torque at the knee and a flexion torque at the hip (external contact torques, EXT). These external contact torques apply great stress to the hamstring muscles. To counteract this effect, the knee flexors and hip extensors, that is, the hamstring muscles that serve both these roles, must produce great flexion torques at the knee and extension torques at the hip. The average peak MSTs at the knee and hip joints are $-203.4 \pm 93.6 \text{ N} \cdot \text{m}$ and $455.2 \pm 198.7 \text{ N} \cdot \text{m}$, respectively, for elite sprinters running at speeds close to 10 m/s. The moment arm of the hamstrings at the knee joint in the sagittal plane is approximately 0.02–0.04 m, thus requiring a hamstring force between 5777 N and 11,554 N to create the measured torques, which is at least 8 times the subjects' average body weight.

The hamstrings are contracting concentrically during this phase. For animal models of injury and during sprinting in

http://dx.doi.org/10.1016/j.jshs.2017.01.012

^{2095-2546/© 2017} Production and hosting by Elsevier B.V. on behalf of Shanghai University of Sport. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

humans, negative work (i.e., energy absorbed) during eccentric contractions has been shown to correlate best with injury.⁸ However, this is not to say that force has nothing to do with injury. Besides, the acknowledged risk factors, such as musculotendon strain, muscle force, flexibility, muscle activation, and contraction rate, comprise a more complex framework in human sprinting than in a well-controlled, isolated eccentric contraction of an in situ animal muscle. Furthermore, the initial phase of stance follows the late swing phase instantaneously; they are continuous phases and may be considered a single period, referred to as the swing-stance transition. During this period, the hamstrings contract eccentrically and then switch rapidly to a concentric contraction. The hamstrings function to extend the hip and flex the knee continuously, not only counteracting the passive effects but also the force generated by the antagonistic muscles. Strength imbalances between the hamstrings and the quadriceps have long been considered possible causes for hamstring strain injuries.9

In summary, we consider the late swing and early stance of sprinting as high-risk phases for incurring hamstring injuries. Our study provides initial answers to why, how, and when peak loads on the hamstring muscles are generated in sprint running: in early stance and late swing. The external GRFs passing anteriorly to the knee and hip (early stance) and the inertial loads produced by the motion of the segments, especially the leg (late swing), require the high hamstring forces.

Authors' contributions

YL designed and carried out the study and drafted the manuscript; YS performed the literature review and helped to draft the manuscript; WZ helped to draft and revise the manuscript; JY participated in the design and coordination of the study and helped to draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

References

- Yu B, Liu H, Garrett WE. Mechanism of hamstring muscle strain injury in sprinting. J Sport Health Sci 2017;6:130–2.
- Schache AG, Dorn TW, Blanch PD, Brown NA, Pandy MG. Mechanics of the human hamstring muscles during sprinting. *Med Sci Sports Exerc* 2012;44:647–58.
- Chumanov ES, Heiderscheit BC, Thelen DG. Hamstring musculotendon dynamics during stance and swing phases of high-speed running. *Med Sci Sports Exerc* 2011;43:525–32.
- Sun Y, Wei S, Zhong Y, Fu W, Li L, Liu Y. How joint torques affect hamstring injury risk in sprinting swing–stance transition. *Med Sci Sports Exerc* 2015;47:373–80.
- Mann R, Sprague P. A kinetic analysis of the ground leg during sprint running. *Res Q Exerc Sport* 1980;51:334–48.
- Orchard JW. Hamstrings are most susceptible to injury during the early stance phase of sprinting. Br J Sports Med 2012;46:88–9.
- Scott SH, Winter DA. Internal forces of chronic running injury sites. *Med Sci Sports Exerc* 1990;22:357–69.
- Garrett WE, Safran MR, Seaber AV, Glisson RR, Ribbeck BM. Biomechanical comparison of stimulated and nonstimulated skeletal muscle pulled to failure. *Am J Sports Med* 1987;15:448–54.
- Opar DA, Williams MD, Shield AJ. Hamstring strain injuries: factors that lead to injury and re-injury. *Sports Med* 2012;42:209–26.