Economical running strategy for East African distance runners

Masaki Ishikawa1*, Kanae Sano1, Yoko Kunimasa1, Toshiaki Oda2, Caroline Nicol3, Akira Ito1 and Paavo V Komi4

Abstract The superior success of East-African endurance runners has stimulated a large amount of interest in exploring valid reasons for their performance, especially for neuromuscular mechanics. This review provides a brief overview of classic neuromuscular interaction during running; and, thereafter, describes a specific neuromuscular interaction alternative to the classic stretch-shortening cycle concept for enhancing the running economy of East-African distance runners.

Keywords: Kenyan runner, elastic utilization, running economy, ultrasonography

Text

During the last couple of decades, one of the most compelling examples of athletic domination is that of East-African runners in international distance running competition. Reliable physiological studies, conducted on the East-African distance runners, have not shown that they would be markedly different in any basic physiological parameters from their e.g., European counterparts. Therefore, their high running economy could not be explained by any of the histochemical and/or biochemical parameters measured from muscle biopsy samples. Consequently, it was clearly concluded, from these reports of Saltin et al.1,2), that one of the possible reasons for their high mechanical efficiency (or running economy) could be the special biomechanical make-up in their structure and function of the triceps surae muscle-tendon unit (MTU)1,2). However, little is known about the mechanical properties of the muscle and tendon in East-African runners and, also, how their neuromuscular system interacts economically and efficiently during running. This review provides a brief overview of classic neuromuscular interaction during stretch-shortening cycle (SSC) exercise; and, thereafter, describes a specific neuromuscular interaction alternative to the classic SSC concept for enhancing the running economy of East-African distance runners.

Since Borelli proposed the concept of an efficient muscle spring mechanism by bow spring3), the muscle mechanics of the power and efficiency enhancements from human counter-movement action4-4) and a kangaroo’s elastic bouncing hop have been examined5). The potentiation phenomenon, due to counter-movements, had been first called as the “wind-up” movement6). This combination forms a “natural” type of muscle function where the muscle undergoes active stretching prior to shortening and is now called SSC7).

By combining the in vivo direct recordings of tendon force with muscle fascicle length changes using musculoskeletal ultrasonography, we can increase our understanding of muscle mechanics related to the high running economy of the East-African distance runners. By definition, the SSC involves the entire MTU, although the muscle fascicles and tendons may experience different changes in length8). It has been suggested that during SSC exercises, muscle activation works to maintain a fixed contractile component (fascicles) length, which corresponds to the plateau phase of the estimated force-length relationship9,10). This effectively favors greater relative force generation in terms of the force-length and force-velocity properties of the contractile component. In addition, a shorter Achilles tendon (AT) moment arm may increase AT force and stretch AT to convert a higher percentage of kinetic energy into elastic energy, thus leading to a superior running economy11,12). From an anatomical point of view, however, the East-African distance runners had greater AT length and its moment arm, and a smaller ankle lever ratio, as compared to Japanese distance runners (Fig. 1). In addition, the East-Africans showed smaller tendon stretching (strain) and shortening during hopping exercises13) (Fig. 2) and running (unpublished

*Correspondence: masakiouhs@gmail.com

1 Graduate School of Sport and Exercise Sciences, Osaka University of Health and Sport Sciences, 1-1 Asashirodai, Kumatoricho, Sennan-gun, Osaka 590-0496, Japan
2 Graduate School of Education, Hyogo University of Teacher Education, 942-1 Shimokume, Kato City, Hyogo 673-1494, Japan
3 Faculté des Sciences du Sport, Aix-Marseille Université, CNRS, CP 910, av. de Luminy, Marseille cedex 09, Marseille, F-13288, France
4 Likes Research Center, University of Jyväskylä, PO Box 35, Jyväskylä, FI-40014, Finland
data). This longer AT can be advantageous for less tendon fatigue/damage due to less AT strain during contact while running\(^{14,15}\). In muscle fascicles, fascicle shortening during the braking phase, at higher running speeds, can enhance the storage and release of elastic energy\(^ {16}\). However, the East-African runners showed smaller fascicle length changes together with less muscle activation of the medial gastrocnemius muscle during the contact phase of hopping exercises (Fig. 2). These differences can be advantageous for a better running economy, based on the relationship between the rate of energy consumption of each active muscle fiber and muscle contractions due to
the Fenn effect\textsuperscript{17}. Consequently, the smaller AT force and stretching with less muscle activation during the braking phase of running might be caused by the longer AT moment arm and ankle joint stiffness for the East-African distance runners.

In conclusion, the neuromuscular interaction utilizing inherent anatomical benefits for the East-African distance runners may be a unique alternative to the classic SSC concept for enhancing the running economy.

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