ECCENTRIC LOAD OF LONG-TERM RUNNING AND ENERGY INTAKE HAVE A MAJOR ROLE IN THE ULTRAMARATHON

TO THE EDITOR: The analyses of ultraendurance athletes have provided new insights into the limits of human performance capacity and into medical complications when going beyond the physical limits. Ultradistance running poses a unique stress on the athlete. In their Viewpoint, Millet et al. (3) argued that determinants of performance in ultraendurance are subjected to a compromise between two main parameters: energy cost and lower limb tissue injury. The latter results from a complex combination of extrinsic factors (training errors including lack of specific strength, inappropriate footwear, inappropriate running surface, and terrain) and intrinsic factors (poor flexibility, biomechanical lower extremity malalignment, anthropometry, previous injury, running experience). Concerning the former, environmental conditions, training, and perhaps most importantly fluid and fuel intake all contribute to energy balance state and race performance. In fact, nutrient intake during ultradistance races has been found to be below the estimated energy cost (1). Despite a low relative intensity the energy cost of running (expressed in mlO2) is increased during ultradistance trail running races (2) compared with level running. This induces a marked negative energy balance state that was shown to reduce serum leptin concentrations during ultramarathon race (5). Thus suboptimal nutrition certainly would result in decreased performance under these circumstances. Finally, it is proposed that the most important factor linking both parameters explaining ultramarathon tolerance is the eccentric load of long-term running causing an association between skeletal muscle damage and impaired renal function through dehydration, rhabdomyolysis, and hemolysis (4) further exacerbated without optimal nutrition intake.

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Stephane Perrey
Professor
Movement To Health (M2H), Euromov

ECONOMY AND SCARCITY IN ULTRAMARATHONS

TO THE EDITOR: Millet et al. (4) raise interesting questions about running economy (RE) as a determinant of performance in ultramarathons compared with shorter distances. They argue successful ultramarathoners adopt stride/running patterns that limit leg tissue damage and muscle fatigue at the expense of RE. Their hypotheses extend original ideas by Nobel laureate A. V. Hill (1), who postulated that “wear and tear” was important in events longer than several hours. In contrast to shorter distances, the number of competitors in ultramarathons is limited, the financial incentives associated with elite performance are low, and top performances do not cluster within 1–3% of world records or winning times in key races (2). These factors make physiological analysis of elite performances challenging. However, when world-class ultramarathoners are considered, it appears that many have the phenotype associated with elite performances at shorter distances. For example, the current world-record holder for 100 km, Takahiro Sunada, ran a 2:10 marathon (and a 1:03 half-marathon) 2 yr after setting the record. Data from the International Amateur Athletic Federation indicates that several top performers at 100 km have run 2:08–2:20 for the marathon. Additionally, historical ultramarathoners (e.g., Ritchie, Fordyce, Klecker) were all superb marathoners (5). These data suggest to us that the same phenotype and physiological factors, including RE, that determine success at the marathon (3) are also likely to determine success in ultramarathons. The scarcity of elite ultramarathoners with a tight cluster of fast times makes it difficult to test hypotheses about RE advanced by Millet et al.

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Michael Joyner
Jonatan R. Ruiz
Alejandro Lucia
Professor
Universidad Europea de Madrid

IS ECCENTRIC CONTRACTION-INDUCED MUSCLE DAMAGE THE KEY FACTOR DETERMINING THE ULTRAMARATHON PERFORMANCE?

TO THE EDITOR: We read the article (5) with great interest, especially that using more energy to minimize muscle damage is necessary for ultramarathons. It is important to distinguish between eccentric contraction-induced muscle damage (ECIMD) and more serious muscle and/or soft tissue injuries. Eccentric contractions induce muscle damage, but muscles adapt rapidly to reduce muscle damage in subsequent exercise bouts (2). It is important to note that leg muscles are less susceptible to ECIMD compared with arm muscles (1), and muscle fiber necrosis does not appear to be induced to a great extent for leg

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muscules even after maximal eccentric contractions (4). Thus it seems unlikely that severe muscle fiber damage is induced in well-trained ultramarathon runners. An interesting question is when in an ultramarathon race ECIMD starts to occur. It might be that “fatigue” results in ECIMD, and a shorter stride length is not a strategy but a result of fatigue and/or muscle damage. We are curious if runners walk down all slopes but run others in a mountain ultramarathon race, they could perform better. Using poles and heavier shoes may not require much extra energy considering that their weight is not that heavy and the running speed is low. Running economy is more influenced by feeding strategy and environmental conditions in marathon (3), which would be also the case for ultramarathon. Further studies are necessary to investigate muscle damage profiles in ultramarathon races with different course profiles (e.g., distance, configuration) and whether ECIMD is the key factor determining the performance.

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Kazunori Nosaka
Professor
Julien Louis
Edith Cowan University

NO EVIDENCE TO SUPPORT SACRIFICING ECONOMY TO IMPROVE RUNNING PERFORMANCE IN THE IDEAL ULTRAMARATHONER

TO THE EDITOR: I read the Viewpoint by Millet et al. (1) with great interest due to the intuitively contradictory title. However, after reading the summary of interesting literature on the characteristics of the modern ultradistance runner, I find no evidence to support the authors “reality” in the ultramarathon.

In so far as a scientific statement speaks about reality, it must be falsifiable: and in so far as it is not falsifiable, it does not speak about reality. – Karl Raimund Popper

Instead, this Viewpoint is based primarily on extrapolating observations made in some of the best ultradistance runners, thus resulting in statements such as “...may even have advantages [large thighs and calves] in terms of resistance to muscle damage.” As acknowledged by Millet et al. (1), other factors may have contributed to such observations, e.g., athletes that specialize in ultradistance running may have been less successful in the shorter distances where larger thigh muscle mass may be a disadvantage. Alternatively, elite east African runners are less likely today to run in ultradistance events, and therefore the best ultramarathoners will emerge from those who do and incidentally may have larger thighs. Therefore, given the choice, I would select as the ideal ultra-distance runner an economical runner who has been running throughout his life (from a very young age), living and training at moderate/high altitude, and running barefoot for survival and therefore less predisposed to injury. I acknowledge that I cannot substantiate this possibility either. Notably, humans have evolved for endurance running well beyond the modern marathon distance of 42.195 km.

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Yannis P. Pitsiladis
Reader in Exercise Physiology
College of Medicine, Veterinary & Life Sciences
Institute of Cardiovascular & Medical Sciences

MINIMIZING OXYGEN CONSUMPTION DURING ULTRAMARATHONS: BEYOND RUNNING ECONOMY

TO THE EDITOR: Millet and colleagues (3) make many interesting points regarding how increasing the metabolic cost of running (Cr) may paradoxically improve ultramarathon performance. Minimizing musculoskeletal and visceral trauma is clearly advantageous, even if Cr increases. Although Cr is not a strong predictor of performance in elite ultramarathoners (1), minimizing oxygen consumption within an individual is still essential for reasons beyond the obvious substrate conservation. First, lower metabolic rates reduce thermogenesis. If the heat accumulation hypothesis (5) is true for ultramarathons, this could prevent hyperthermia-induced central fatigue. Even if the controversial critical internal temperature threshold theory is not applicable, lower body temperatures require less heat exchange and sweating. The combination of less blood flow to the skin and reduced fluid loss should allow greater blood flow to the muscles at a cardiac output. Second, lower oxygen consumption may prevent excessive generation of reactive oxygen species and thus reduce oxidative stress. Exercise-induced oxidative stress leads to neuromuscular fatigue, decreased mitochondrial efficiency, and muscle damage through multiple mechanisms (2, 4), and can therefore ultimately reduce running velocity. Thus shorter strides may be viewed as a consequence of fatigue, rather than a primary mechanism to prevent orthopedic insult.

Last, it is difficult to generalize research regarding ultramarathon performance, given races range from 50 km through beyond 1,000 miles. Furthermore, most of the world’s top marathoners have not seriously attempted ultramarathons. Therefore, it is unknown whether observations in top ultramarathoners are truly representative of optimal ultra-running performance.

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James M. Smoliga
Associate Professor of Physiology
High Point University
Gerald S. Zavorsky
Associate Professor
Director of Human Physiology Laboratory
Marywood University
Scranton, Pennsylvania

Letter To The Editor

OXIDATIVE CAPACITY/RUNNING ECONOMY IS ESSENTIAL FOR MINIMIZING MUSCLE DAMAGE DURING THE ULTRAMARATHON

TO THE EDITOR: The article by Millet et al. (4) raises intriguing questions regarding physiological and biomechanical parameters that contribute to ultramarathon vs. traditional running performance. The authors suggest that traditional factors thought to contribute toward greater running economy, such as longer Achilles tendons, lower body fat, greater percentage of type I fibers, and differences in mitochondrial functional capacity, are less important when determining ultramarathon performance. Although the notion presented supports the notion that ultramarathon performance is determined more by the ability to alleviate musculotendinous and osteoarticular damage, it is likely that these data are confounded by the fact that few elite distance runners have converted to the ultramarathon (1). The number of participants engaging in the ultramarathon is sparse compared with the marathon; therefore it is likely that greater participation from elite distance runners would lead to significantly greater achievements in the ultramarathon distance. For example, Alberto Salazar was able to win the 56-mile Comrades Marathon at the age of 36 (over 10 yr following his Boston and New York City Marathon wins). Prolonged oxidative stress reduces mitochondrial function dramatically (5). Elevated running economy and skeletal muscle oxidative capacity are both important for reducing oxidative stress and slowing mitochondrial damage at any relative intensity (2, 3, 5). We agree that prevention of articular, tendon, and muscle damage is important in ultramarathons; however, we feel that muscle oxidative capacity and running economy not only can increase ultramarathon running speed but will indirectly reduce articular, tendon, and muscle damage.

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SACRIFICING ECONOMY TO IMPROVE RUNNING PERFORMANCE—A REALITY IN THE ULTRAMARATHON?

TO THE EDITOR: Ultra-endurance exercise is associated with a wide range of changes in parameters associated with injury in muscle and cartilage, with the greatest risk for damage seemingly occurring in the latter half of a race (1–4), well beyond the time and distance limits of marathon running. However, for success in ultramarathon competition, as for marathon running, it is important to achieve a balance between the energy cost of locomotion (Cr) and the maximal sustainable fraction (F) of V\text{O}_{2\text{max}}. But, as discussed by Millet et al. (5) the balance will be different in ultramarathon compared with marathon running. Musculotendinous and osteoarticular damage, as well as GI disorders, will impose additional limitations on F in ultramarathon running not found (to the same degree) in marathon running, resulting in potentially adverse responses at the whole body level. Although V\text{O}_{2\text{max}}, in determining F, will again be a positive criteria of performance other factors, particularly those accounting for Cr, it may not apply to ultramarathon running. Thus criteria exemplified in East African marathon runners may not apply to those undertaking ultramarathon races. Criteria that help minimize tissue damage and GI distress, even if these result in a lowering of Cr, may well be beneficial to ultramarathon performance, despite that such criteria would be contraindicated in the case of marathon runners. However, in respect to physio-psychological factors it is generally agreed that psychological-motivational factors play a more important role in ultramarathon running over 100 km than other factors including accumulative damage.

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Chang K. Kim
Professor of Physiology
Hyo J. Kim
Korea National Sport University