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INTRODUCTION

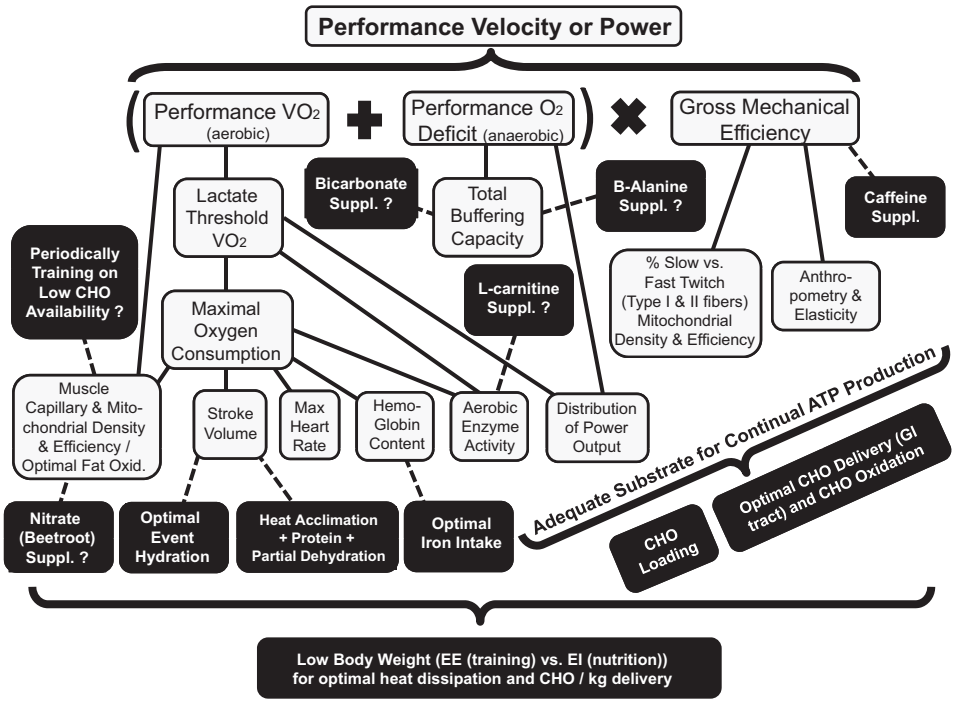
Nutritional triggers to adaptation and performance[1]

The interactions between exercise physiology and nutrition are more intimately linked than most realize. At its fundamental level, the adaptation to training is a balance between energy expenditure (exercise) and energy intake (nutrition), which ultimately dictates the adaptive response of the individual, whether it be an elite athlete or someone new to exercise. Certainly, exercise stimulus is essential to drive adaptation, but proper nutritional substrates can optimize this response. Furthermore, limits to performance can partially be overcome through informed use of several nutritional supplementation strategies. Thus, over the years sports nutrition has evolved from a niche discipline into a very important element of sport performance. In many ways, some nutritional interventions can now be viewed as potent "triggers" for training adaptation and performance. Coaches and physiologists spend much time deliberating over their training and physiological stimuli. But, very few scientists and coaches think about the substrates (e.g., nutrition/hydration) that optimize the stimuli: how nutritional triggers can optimize the training response and performance of the athlete.

This special issue of *Applied Physiology, Nutrition, and Metabolism* on Nutritional Triggers to Adaptation and Performance aims to highlight this emerging field. Please refer to Fig. 1 for an example of the contemporary thinking in this area. This is the physiologically based concept put forth by Joyner and Coyle in 2008 to highlight the key performance determinates for endurance velocity and power. Their original published framework is highlighted in the white boxes, while the black boxes highlight the areas where nutritional "triggers" may play a very important potential role in maximizing training adaptation and (or) performance outcomes. As evidence of the proliferation of novel nutritional interventions, at least 5 of these black boxes were not even considered in this figure 6 years ago!

Accordingly, in recent years a handfull of nutritional supplement interventions have come to the forefront, with considerable emerging scientific evidence for performance efficacy, of which many are highlighted in this special issue. One major innovative area that has emerged since 2009 is the impact that nitrates and associated nitrate precursors (e.g., beetroot juice or pomegranate extract) may have on blood flow, metabolism, and performance. Indeed, original papers on this topical area by Trexler et al. (2014), Lane et al. (2014) and Hoon et al. (2014), and then expertly reviewed by Prof. Jones (Jones 2014), one of the foremost global researchers in the area, comprise a third of the papers. "What is old becomes new again" is a great way to summarize several reviews on topics that have been around for a long time: iron, vitamin E, protein and carbohydrate. Hinton et al. (2014) eloquently review the complexities around iron absorption, iron anemia, and performance, including the new data on the pro-inflammatory hormone hepci-

Fig. 1. Overview of physiological and nutritional determinates of endurance performance. (From Joyner and Coyle 2008, adapted with permission of the Journal of Physiology, vol. 586, p. XX, © John Wiley and Sons 2008.) A question mark (?) highlights the requirement for more scientific validation. CHO, carbohydrate; EE, energy expenditure; EI, energy intake; GI, gastrointestinal; Oxid., oxidation; Suppl., supplementation; VO_2, oxygen consumption.



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[1]This introduction is a part of a Special Issue entitled Nutritional Triggers to Adaptation and Performance.

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din, which antagonizes iron absorption, with a meta-analysis by Stepanyan et al. (2014) on vitamin E and inflammation also being featured. Additionally, Moore et al. (2014) and Stellingwerff et al. (2014) examine the efficacy of different proteins (whey vs. casein, timing, and amount) and carbohydrate (type, amount, timing, exercise duration), respectively, which directly impact training adaptation and performance. Finally, several other independent studies highlight some long-standing supplements, caffeine, and bicarbonate (Christensen et al. 2014) and the ever novel and emerging areas of supplements such as bovine colostrum (Morrison et al. 2014), omega-3–supplementation (Gerling et al. 2014), and carbohydrate mouth-washing (Watson et al. 2014).

Unfortunately, the consumer-driven world is filled with products that nearly *all* claim to enhance performance and health, but research is generally unable to keep pace with the number of new products appearing on the market every year. While some sport nutrition interventions can provide true value in the nutritional program of the individual, the majority of supplements and sports foods are either untested or have failed to live up to expectations in the studies that have been conducted. This provides a challenge for those working with elite athletes who eagerly seek products or strategies that might enhance their performance by even small margins. Hopefully this special issue, comprising expert reviews and original scientific articles, will aid in providing some much needed exposure on the positive impact that nutrition can have in the adaptive responses of athletes.

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References

Christensen, P.M., Petersen, M.H., Friis, S.N., and Bangsbo, J. 2014. Caffeine, but not bicarbonate, improves 6 min maximal performance in elite rowers. Appl. Physiol. Nutr. Metab. **39**(9): 1058–1063. doi:10.1139/apnm-2013-0577.

Gerling, C.J., Whitfield, J., Mukai, K., and Spriet, L.L. 2014. Variable effects of 12-weeks of omega-3 supplementation on resting skeletal muscle metabolism. Appl. Physiol. Nutr. Metab. **39**(9): 1083–1091. doi:10.1139/apnm-2014-0049.

Hinton, P.S. 2014. Iron and the endurance athlete.Appl. Physiol. Nutr. Metab. **39**(9): 1012–1018. doi:10.1139/apnm-2014-0147.

Hoon, M.W., Hopkins, W.G., Jones, A.M., Martin, D.T., Halson, S.L., West, N.P., Johnson, N.A., and Burke, L.M. 2014. Nitrate supplementation and high-intensity performance in competitive cyclists. Appl. Physiol. Nutr. Metab. **39**(9): 1043–1049. doi:10.1139/apnm-2013-0574.

Jones, A.M. 2014. Influence of dietary nitrate on the physiological determinants of exercise performance: a critical review. Appl. Physiol. Nutr. Metab. **39**(9): 1019–1028. doi:10.1139/apnm-2014-0036.

Joyner, M.J., and Coyle, E.F. 2008. Endurance exercise performance: the physiology of champions. J. Physiol. **586**: 35–44. PMID:17901124.

Lane, S.C., Hawley, J.A., Desbrow, B., Jones, A.M., Blackwell, J.R., Ross, M.L., et al. 2014. Single and combined effects of beetroot juice and caffeine supplementation on cycling time trial performance. Appl. Physiol. Nutr. Metab. **39**(9): 1050–1057. doi:10.1139/apnm-2013-0336.

Moore, D.R., Camera, D.M., Areta, J.L., and Hawley, J.A. 2014. Beyond muscle hypertrophy: why dietary protein is important for endurance athletes. Appl. Physiol. Nutr. Metab. **39**(9): 987–997. doi:10.1139/apnm-2013-0591.

Morrison, S.A., Cheung, S.S., and Cotter, J.D. 2014. Bovine colostrum, training status, and gastrointestinal permeability during exercise in the heat: a placebo-controlled double-blind study. Appl. Physiol. Nutr. Metab. **39**(9): 1070–1082. doi:10.1139/apnm-2013-0583.

Stellingwerff, T., and Cox, G.R. 2014. Systematic review: Carbohydrate supplementation on exercise performance or capacity of varying durations. Appl. Physiol. Nutr. Metab. **39**(9): 998–1011. doi:10.1139/apnm-2014-0027.

Stepanyan, V., Crowe, M., Haleagrahara, N., and Bowden, B. 2014. Effects of vitamin E supplementation on exercise-induced oxidative stress: a meta-analysis. Appl. Physiol. Nutr. Metab. **39**(9): 1029–1037. doi:10.1139/apnm-2013-0566.

Trexler, E.T., Smith-Ryan, A.E., Melvin, M.N., Roelofs, E.J., and Wingfield, H.L. 2014. Effects of pomegranate extract on blood flow and running time to exhaustion. Appl. Physiol. Nutr. Metab. **39**(9): 1038–1042. doi:10.1139/apnm-2014-0137.

Watson, P., Nichols, D., and Cordery, P. 2014. Mouth rinsing with a carbohydrate solution does not influence cycle time trial performance in the heat. Appl. Physiol. Nutr. Metab. **39**(9): 1064–1069. doi:10.1139/apnm-2013-0413.