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Commentary on *Effects of High-intensity Training on Performance and Physiology of Endurance Athletes*

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Paton and Hopkins have produced a comprehensive review of the effects of training on performance and physiology of endurance athletes. Despite the volume of research on running over recent decades there is little summarized information for coaches and scientists on the impact of high intensity training. The authors appear to have cited all the relevant studies in the literature pertaining to well-trained runners. The article has excellent coverage of common training activities including moderate and high intensity interval running, plyometrics, and resistance training.

The layout of the review actually takes the form of a traditional experimental paper including Methods, Findings and Conclusions. This is slightly unusual but the approach is crystal clear and makes the review easy for the reader to follow and grasp the essential findings. The three tables and five appendices are comprehensive and provide an excellent summary of the effects of resistance training and interval training on changes in physiological characteristics and performance. The statistical approach is very elegant, as we have come to expect from the Hopkins stable of co-researchers and students. The transformation of changes in performance to percent changes in power provides a comparable basis on which to compare the relevant studies and to determine the effectiveness of different types of training.

Some points in the review that could be debated include the contention that all but one study was performed in the non-competitive phase of the athlete's program, and the details on the patterns of increasing the effort and level of performance within and between running intervals in a given set. The traditional distinction of training and competitive phases within the seasonal training plan is somewhat arbitrary in practice as many athletes compete in lower level competitions during various training phases prior to the actual competition phase. The authors haven't directly addressed the issue of incremental training sets where many athletes like to gradually increase the effort or intensity of successive intervals, through the main part of the set or session. Another consideration for readers is that many of the performance tests used in the various studies were simulated laboratory tests. This approach may not necessarily represent true competitive performance as motivation and desire to achieve the best possible effort may be compromised in a laboratory environment.

Using maximal oxygen uptake, economy and lactate threshold as the three major components of endurance fitness is a logical approach and gives scientists and coaches direction into what training improves various components of aerobic fitness. At the AIS we use a similar battery of tests to determine performance capabilities in highly trained distance runners and have also found that different training methods develop these systems independently. The aim of this approach is to identify an athlete's strengths and weaknesses and prescribe training accordingly. The current article by Paton and Hopkins also provides useful discussion on the specific adaptations for each of the three components of aerobic fitness, allowing coaches to incorporate specific training methods to improve maximal oxygen uptake, economy and lactate threshold.

During the last four years the running economy of distance runners has been the focus of much of our research here at the AIS. In relation to the current review we also investigated the effect of plyometric training on running economy in highly trained distance runners. In this study we demonstrated that 9 wk of plyometric training improved running economy in elite distance runners at speeds typically undertaken by these athletes during training/competition. The mechanisms underlying the improved running economy after plyometrics appeared to be unrelated to changes in cardiorespiratory variables or shifts in substrate utilization, suggesting that such enhancements may have been predominantly elicited through enhanced muscular power and/or elastic energy return, or alternatively through better coordination and timing of ground force application. We consider that the improved running economy at 18 $km.h^{-1}$ is a practically significant effect of plyometric training.

In summary, this review fills a large gap in the sports physiology and performance literature. We strongly recommend it to scientifically-minded coaches, undergraduate and graduate students, practicing sports scientists, and sports performance researchers.

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