
ROLE OF PHYSIOLOGY IN CRICKET

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Despite its long history and global appeal, relatively little is known about the physiological and other requirements of cricket. It has been suggested that the physiological demands of cricket are relatively mild, except in fast bowlers during prolonged bowling spells in warm conditions. However, the physiological demands of cricket may be underestimated because of the intermittent nature of the activity and the generally inadequate understanding of the physiological demands of intermittent activity. Here, we review published studies of the physiology of cricket. We propose that no current model used to analyse the nature of exercise fatigue (i.e. the cardiovascular anaerobic model, the energy supply energy depletion model, the muscle power muscle recruitment model) can adequately explain the fatigue experienced during cricket.

Keywords: aerobic capacity, anaerobic capacity, cricket, eccentric exercise, exercise models, strength training.

Reviews

Models for understanding the physiological demands of cricket

Although exercise physiologists have perhaps yet to embrace the concept fully, it is clear that much of what is written about the different physiological limitations to exercise can only be interpreted according to specific models that have evolved about the nature of the physio-logical factors that limit exercise performance (Noakes, 1997, 2000). These models \pm the classic cardiovascular \pm anaerobic model, the energy supply energy depletion model, the muscle power muscle recruitment

model, the biomechanical model \pm have been described else-where and will be used here to evaluate further the physiological factors that determine physical performance in cricket. It should be understood, however, that cricket is, above all else, a game requiring inordinate physical skills and mental aptitude, including the ability to concentrate intensely for very prolonged periods, and for which high physical fitness cannot, on its own, fully compensate. However, we are of the opinion that modern cricketers will benefit from superior physical fitness, regardless of their skill. Thus we argue that, for cricketers of equal skill, physiological factors determining their fitness will ultimately predict their success and longevity in the sport.

The classic cardiovascular anaerobic model of exercise physiology

The classic model holds that there is an exercise intensity or workload above which the output of the heart reaches a limiting maximum, so that any activity above that exercise intensity must be undertaken in the presence of an inadequate oxygen and blood supply to the active skeletal muscles. Faced with an inadequate blood and oxygen supply, the active muscles must contract 'anaerobically', that is with an inadequate oxygen supply. This model further holds that anaerobic energy production produces metabolic by-products, the accumulation of which inhibit both energy production and muscle contractile activity, leading to fatigue and the termination of exercise. The historical basis for this work are the original studies of A.V. Hill and his colleagues in the 1920s (Hill and Lupton, 1923; Hill *et al.*, 1924a,b).

Noakes and Durandt argued that, if one knows the duration for which any activity is undertaken and the metabolic pathways that provide fuel during activity of that intensity and duration, then one can predict the metabolic factors that are likely to limit performance in activities of any duration or intensity. This knowledge is then used to determine the most appropriate training methods, according to the metabolic pathways that are activated and, presumably, trained by the different exercise intensities and durations used in training.

Regardless of this ongoing debate, there is little relevance of these models to cricket physiology, as most activities in cricket are of relatively short duration, lasting perhaps at most 10 s, and are seldom of a maximal all-out nature. Exercise of this short duration is fuelled mainly by phosphagen breakdown (Fig. 2) with restoration of the phosphagen stores during recovery from effort. Phosphagen resynthesis occurs from oxidative metabolism in the mitochondria of the active muscles. As even the most vigorous activities in cricket would not induce phosphagen depletion in the active muscles, it is clear that this model has little relevance to an analysis of the physiological limitations in cricket.

Accordingly, this governor would prevent the development of myocardial or cerebral hypoxia during exercise at altitude, or neuroglycopenic cerebral insult through hypoglycaemia, or whole-body damage caused by an elevated body temperature in heatstroke (Noakes, 1997, 1998).

Not only are cricketers protected from the risk of developing hypoglycaemia by the fortuitous scheduling of tea or lunch breaks at two-hourly intervals during matches, they are not exposed to the risks of playing at very high altitudes. This is because of the absence of sufficiently large \bar{v} at playing surfaces at the high altitudes encountered on the Asian subcontinent and for historical reasons, the Tibetans, Nepalese, Peruvians and Colombians do not play cricket. The only likely risk to cricketers is that posed by the development of elevated body temperatures.

In general, the development of heat injury requires both high rates of energy expenditure and severe environmental conditions. Although cricket is occasionally played in severe environmental conditions in Africa, Australia and India, from first principles we would again assume that the rates of energy expenditure during cricket are too low (Fig. 1) to induce hyperthermia.

To the best of our knowledge, there are no publications reporting the rise in body temperature in cricketers during competition. The only study to suggest relatively high rates of heat production in some fast bowlers is that of Gore *et al.* (1993), in

which sweat rates of Australian fast bowlers were measured in different environmental conditions, including cool, warm and hot days.

However, it is unlikely that a cricket fast bowler would be able to sustain his effort for much more than about 1 h; in contrast, marathon runners can sustain these high work rates for 2 ± 3 h, after which time they are at risk of developing heat injury.

It is unlikely, therefore, that high rectal temperatures, which are determined principally by the rate of metabolic heat production, would be sustained for sufficiently long to impact on the performance of cricketers. The only exceptions are fast bowlers bowling for more than 1 h in a hot and humid environment, or batsmen in a one-day international forced to run many singles in the hot and humid conditions that exist during the summer daylight hours on the Asian subcontinent and in Australia.

That bowlers can occasionally achieve such high sweat rates raises the following question: 'What intensity of effort is sustained by the modern cricketer?' Although the measurement of oxygen consumption during exercise provides the most accurate method for determining exercise intensity, this is not possible during cricket. The only means currently available for estimating the exercise intensity during cricket is to measure heart rates during batting and bowling.

In summary, the early predictions of Fletcher (1955) appear to have been confirmed by more recent studies, all of which have shown that the rates of energy expenditure during cricket are relatively low, with the only possible exception of fast bowlers. Thus, from a physiological point of view, none of the models traditionally used to explain exercise fatigue in athletes appears to be particularly relevant to cricket. All these models suggest that cricketers should be able to play cricket without fatigue for days on end. Although no data are available, it is commonly believed that speed and accuracy decline after 6 ± 8 overs of fast bowling and that batsmen, particularly during a one-day game, can become fatigued in an innings in which they score 100 or more runs. This suggests that our current understanding of the physiology of fatigue is unsatisfactory when applied to such

activities as cricket, in which short bouts of high-intensity exercise are interspersed with prolonged periods at much lower exercise intensities. Most research on this topic has focused on repeated bouts of high-intensity exercise repeated at much shorter intervals than typically occur in cricket (Bogdanis *et al.*, 1994, 1996).

When viewed in this context, it is apparent that the demands of bowling and batting in one-day cricket are not insubstantial. It is clear that elite players in particular need to be athletic to be able to reproduce these performances frequently, especially during a series of one-day international matches, in which they must partake in 3.5 h of frequently vigorous @elding.

Perhaps the real stress of cricket results from damage (Morgan and Allen, 1999) caused by repeated eccentric muscle contractions that occur during fast bowling but also in the repeated decelerations that occur when turning during batting or @elding. It is clear that shuttle running, which simulates the acceleration, deceleration and turning required in running between the wickets, is suý cient to induce muscle damage (Thompson *et al.*, 1999). The ability to cope with repeated eccentric muscle contractions may require substantial muscle strength to reduce the extent of muscle damage.

Physiological requirements of cricket

Conclusions

The results presented here show that little is known about the physiological requirements of cricket. How-ever, the Andhra Pradeshn cricketers assessed by us were as `@t' as international rugby players, although they were smaller and lighter. This suggests that a sporting selection process may occur in Andhra Pradeshn sport such that athletes who are physically superior are selected into different sports according to body size (and skill). It would appear that the best Andhra Pradesh cricketers have the special skills required of cricketers but, in addition, have a superior physical endow-ment that, had they been heavier and taller, might have also allowed them to represent Andhra Pradesh in other sports, especially rugby. Their smaller size precludes them from being as successful in rugby. However, a smaller

size might be a selective advantage, especially for batting. In the present study, it was notable that most batsmen were shorter than the other members of the team. This superior genetic endowment may be more important than physical training in determining 'fitness'.

Finally, the very high 'fitness' of these cricketers suggests that cricket is far more demanding physio-logically than is presently recognized. The repeated episodes of eccentric muscle contraction could explain this unexpected finding. If this is the case, greater attention should be paid to eccentric muscle strengthening, especially in fast bowlers.

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