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The Physical Demands of Batting and Fast Bowling in Cricket

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1. Introduction

Even though cricket is one of the oldest organized sports, there are very few studies on the physical demands of the game (Woolmer & Noakes, 2008; Christie & King, 2008; Christie et al., 2008). Batting and bowling are intermittent in nature with the demands placed on the players being dictated by the type of match being played. Due to this stop-start nature of cricket, accurate assessments are often difficult and as such, research is sparse (Bartlett, 2003) and as a consequence, there are few scientifically sound training programmes for cricketers. In fact, the idea that cricketers need to be well trained is a relatively new one (Woolmer & Noakes, 2008). Historically cricket players never trained as hard as other sportsmen in team based sports such as rugby and soccer and in fact, many were overweight which dispelled any reason to be trained for their sport (Woolmer & Noakes, 2008). It wasn't until the Australians (cricket) and New Zealanders (rugby) demonstrated that, by focusing on physical training, performance benefits would be derived, that this started to change. This was a direct consequence of more scientifically based physical training programmes prior to their Cricket and Rugby World Cup wins in 1991 and 1987 respectively.

Further, the increased demands being placed on many cricketers now provide further need for them to be in peak physical condition not only for performance, but also for prevention of injury. International cricketers are now exposed to greater demands reflected by more five-and one day matches per season, longer seasons and more frequent touring (Noakes & Durandt, 2000). For example, during the 1998/1999 cricket season, the South African cricket team played eight five-day Test matches, 17 one-day international games and were eligible to play in eight four-day and ten one-day provincial (county) cricket matches – 99 days of playing (Woolmer & Noakes, 2008). In 1970, in contrast, players were asked to play 35 days of cricket (Woolmer & Noakes, 2008). Woolmer & Noakes (2008) therefore argue that only the best physically prepared cricketers will perform better, more consistently and with fewer injuries and, in turn, will enjoy longer and more illustrious careers. Thus, understanding the physiological demands placed on players and in particular batsmen and bowlers is imperative. Having said that, it is important to acknowledge the skills and mental aptitude needed to succeed in the game of cricket and that being physically trained cannot, on its own, fully compensate (Noakes & Durandt, 2000). However, being physically well

conditioned will differentiate between two players of equal skill and, as such, enhancing our understanding of the physical requirements of the game can assist in bringing the game forward. Despite the limited data on cricket, teams that have embraced the concept that research in the sport contributes to improved performance, have excelled over the last few decades (Mansigh, 2006). Science and cricket is a fairly new marriage and only now do many of the international teams realize the gap between those who incorporate science and those who rely solely on talent (Mansigh, 2006).

2. Physical characteristics of cricketers

As a generalization, it has been found that batsmen tend to be smaller and lighter than bowlers (Stretch, 1987; Noakes & Durandt, 2000; Bartlett, 2003) but that they have similar morphological profiles with both batsmen and bowlers averaging approximately 12-14% body fat (Figure 2) (Noakes & Durandt, 2000; Bartlett, 2003). Batsmen also have higher predicted maximal oxygen uptake values and faster running (simulated three runs protocol) with quicker turn times than bowlers but have similar strength and 35 m sprint performances (Noakes & Durandt, 2000). When compared to rugby players, cricketers demonstrate similar performance characteristics (Figure 2). This is despite the fact that rugby is typically viewed as more physically demanding requiring players to be well trained. Cricket, in contrast, has tended to be viewed as less physically demanding requiring less training (Fletcher, 1955). Data on South African international rugby and cricket players clearly shows differences in morphology as well as performance with cricketers reaching higher levels on the typical shuttle run test (Figure 1). Further, there are no reported differences in strength measures between the two groups (Figure 2) which is interesting, as rugby players are also viewed as stronger possibly due to the larger size (Figure 2).

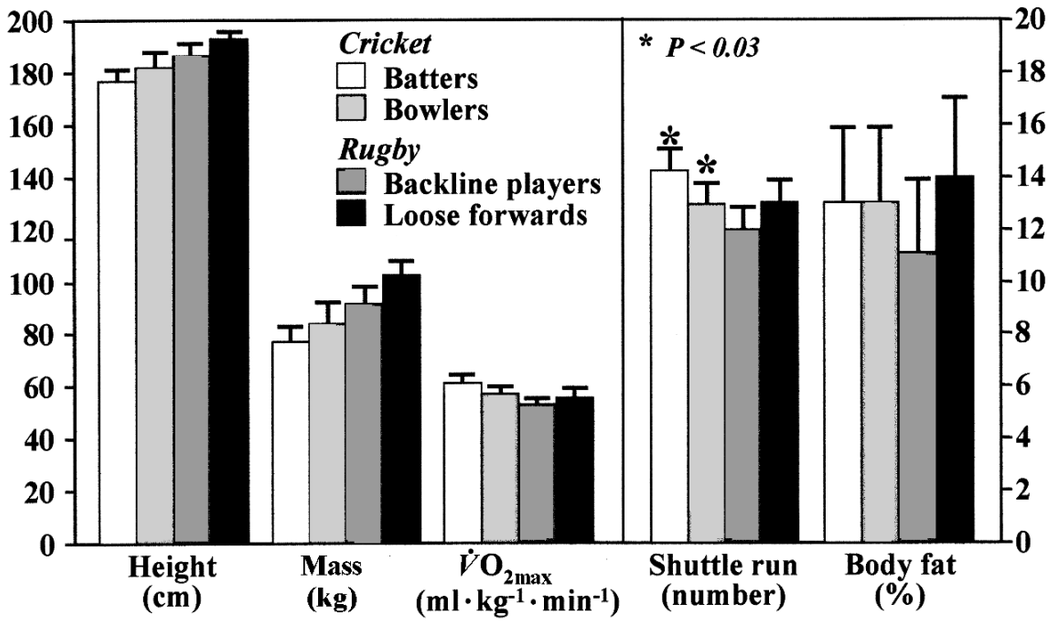


Fig. 1. Comparison of South African international cricket and rugby players (Taken from Noakes & Durandt, 2000).

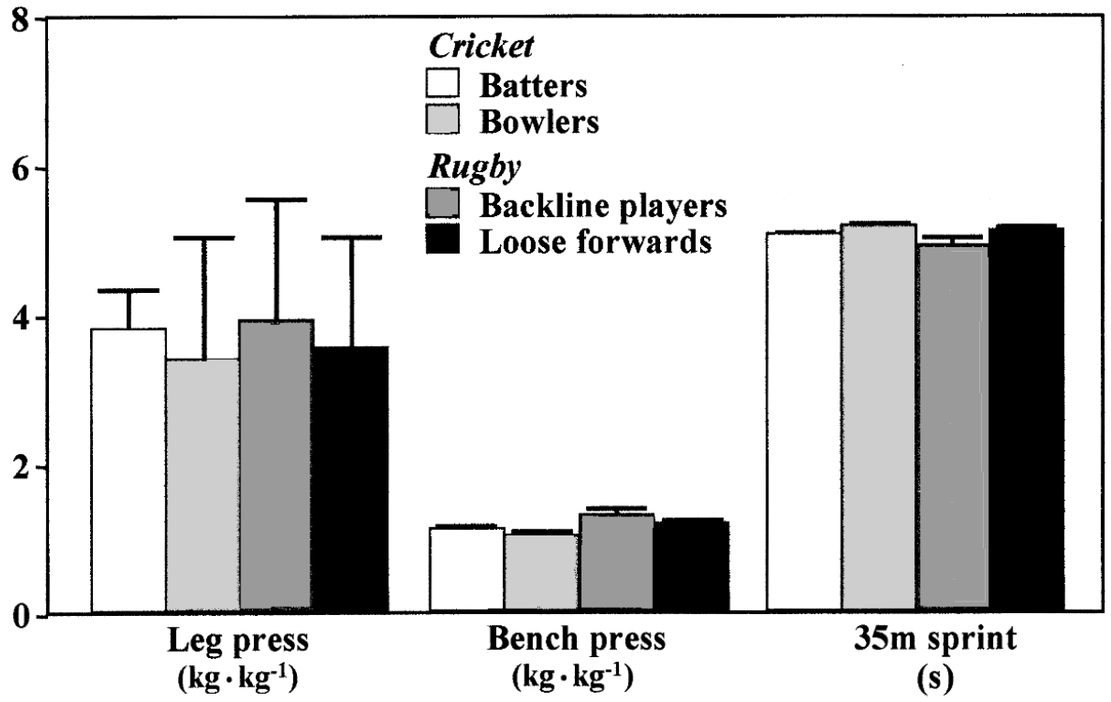


Fig. 2. Strength comparisons between elite South African rugby and cricket players (Taken from Noakes & Durandt, 2000).

3. Most frequent injuries in cricket

There have been many reports on the types of injuries incurred by elite teams worldwide (Orchard et al., 2006; Leary & White, 2000) with a more recent paper reporting on injuries at all levels of play including recreational cricketers (Walker et al., 2010). These latter authors found that of all age groups, the upper (36%) and lower (31%) limbs were most commonly injured. This was higher than that reported by Stretch (1995) who found a 23% occurrence of lower limb injuries in school boys. However, with respect to more adult and elite players, the incidence rate is higher and between 38% and 50% (Leary & White, 2000; Orchard et al., 2002). Walker et al. (2010) reported that contact with the ball or bat was the dominant mechanism of injury for those under age 50 while overexertion, strenuous or repetitive movement, slips and falls were the mechanisms for those over age 50 (Walker et al., 2010). Walker et al. (2010) showed that 35% of injuries to the lower limb areas were as a result of strains and sprains to muscles in the lower limb region. This was the highest percentage of all injuries to the lower limb region and was most obvious in the 30-39 year age group; the typical age at which cricketers 'peak' and are playing at top level. This is important considering the high demands placed on the lower limb musculature when sprinting and turning between the wickets and when sprinting and during the rapid acceleration and deceleration in the run-up and delivery of the ball when fast bowling (Christie et al., 2011b). It is contended that this repeated eccentric loading of the lower limb musculature is the real source of stress for cricket players (Noakes & Durandt, 2000) and which would reflect in more lower limb muscle sprains and strains. Injury research on bowlers has largely focused on low-back injuries in fast bowling and the current thinking is that the mixed technique results in the

most injuries (Bartlett, 2003). The loading on the bowler's musculoskeletal system at back-foot and front-foot strike is a potential risk for not only lower back injury (Bartlett, 2003) but also lower limb musculoskeletal strain. Peak vertical forces for back- and front-foot strike are 2.4 and 5.8 times body weight (Hurion et al., 2000). In terms of increasing playing hours and increased risk of injury, surprisingly, despite a 30% increase in player hours over more than a decade, match injury incidence has remained relatively constant (Orchard et al., 2006) which may reflect improvements in injury detection and treatment (Mansigh, 2006).

4. Physiological demands of cricket

One of the first studies which attempted to assess the energy cost of cricket calculated that the mean energy expenditure of cricketers, during a five-match test series, was 86.4 $kcal.m^2.h^{-1}$ (Fletcher, 1955). This equates to an energy expenditure of approximately 650 $kJ.h^{-1}$ for an average cricketer with a body surface area (BSA) of 1.8 m^2 (Christie et al., 2008). These calculations, together with data recorded using indirect calorimetry with cricketers playing in the nets, led to the development of Figure 3 (redrawn by Noakes & Durandt, 2000).

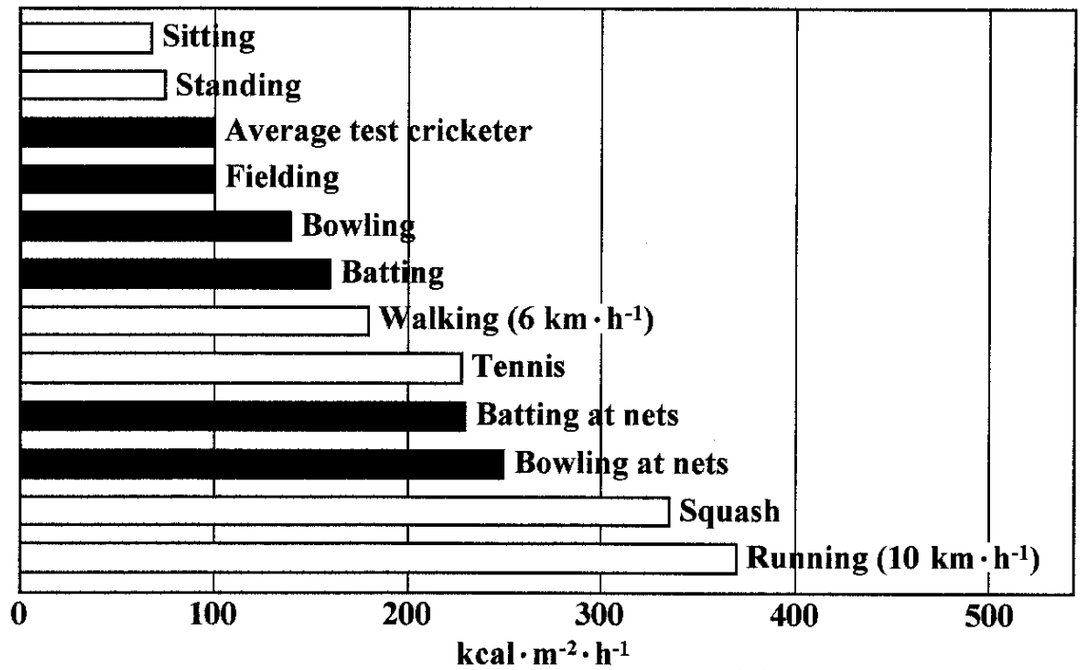


Fig. 3. The energy demands of different cricketing activities compared with other sports and activities. (Redrawn by Noakes & Durandt, 2000 from Fletcher, 1955).

Fletcher's data suggested that the energy demands of cricket are only slightly more than that required to stand (Christie et al., 2008) which led to the understanding that cricket was physically undemanding requiring more skill than "fitness" (Noakes & Durandt, 2000). However, it must be noted, that Fletcher included time spent sitting watching the game in his calculations (Petersen et al., 2010). Despite this, these findings were confirmed more recently by Rudkin and O'Donoghue (2008) who, after analyzing first-class fielding in the United Kingdom, concluded that cricket is physically undemanding. In contrast, studies

from our laboratory, simulating one day batting, have estimated much higher energy demands (Christie et al., 2008; Christie et al., 2011a).

4.1 Physiological demands of batting

Noakes & Durandt (2000) estimated that during a one-day game, a hypothetical player scoring 100 runs, made up of 50 singles, 20 twos, 10 threes and 20 fours, would cover a distance of 3.2 km in an activity time of 8 minutes. Average running speed would be 24 $km.h^{-1}$ with at least 110 decelerations required (Noakes & Durandt, 2000). From this, these authors deduce that the physiological demands of batting in a one-day game are substantial. Players need to be well trained to do this as they are also required to field for 3.5 hours which adds to the stress placed on them.

The first study done in our laboratory, focusing specifically on the physiological demands of batting, looked at 10 batsmen receiving one delivery every 30 s with a total of 7 overs (42 deliveries) faced (Christie et al., 2008). After every 3rd delivery the player was required to complete one shuttle run at full pace. The two popping creases were set 17.68 m apart. The 2 by 2 singles run per over simulated the high work rate likely to be achieved after the 15th over in a high-scoring one-day match (King et al., 2001). The total distance run by each player was approximately 495 m. The 30 s period of inactivity between deliveries was to account for the bowler walking back to his 'mark'. The 1-minute break between each over was reflective of a change in bowler. The results were that heart rate increased significantly during the first three overs (Figure 4) and then more marginally for the remaining four overs during which mean heart rate was 152 $bt.min^{-1}$ (Christie et al., 2008).

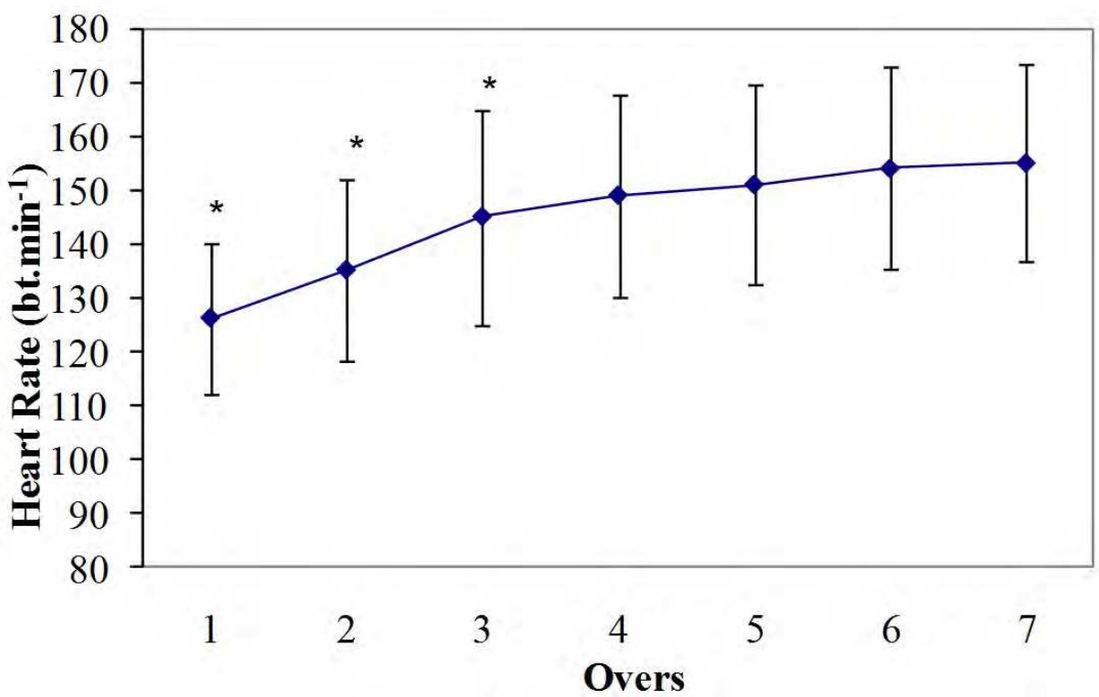


Fig. 4. Mean heart rate responses ($bt.min^{-1}$) from the first to the seventh Over. *(* Denotes a significant increase in heart rate for the first three Overs)*

Oxygen consumption during the first over (23.5 $ml.kg^{-1}.min^{-1}$) was significantly ($P < 0.05$) lower than the remaining six overs (mean of 27.3 $ml.kg^{-1}.min^{-1}$) which demonstrated a 'steady-state' response (Christie et al., 2008). Further, the mean energy cost of the work bout was 2536 $kJ.h^{-1}$ (301 $kcal.m^2.h^{-1}$) (Christie et al., 2008).

This initial research in our laboratory therefore demonstrated that batting was a lot more physically taxing than previously thought. Further, these findings also contradicted the notion of Gore et al. (1993) that during a ODI a batsman's heart rate rarely rises above 128 $bt.min^{-1}$.

A subsequent study in our laboratory, with a slightly altered work bout due to more recent time motion analyses (35 second break between balls as well as a 75 second break between overs as well as a single sprint per ball), found even higher responses (Christie et al., 2011a). During the first over, heart rate increased significantly ($p<0.01$) to 142 $bt.min^{-1}$ and then continued to increase until the end of the third over (161 $bt.min^{-1}$). Thereafter heart rate stabilised and remained between 161 $bt.min^{-1}$ and 167 $bt.min^{-1}$ (final over). Oxygen consumption and energy expenditure increased significantly ($p<0.01$) until the end of the second over after which both responses stabilised. VO_2 stabilised between 27 and 28 $mlO_2.kg^{-1}.min^{-1}$ in the final six overs while energy expenditure remained constant at 11 $kcal.min^{-1}$. These studies confirmed our belief in the higher physiological demands of batting.

4.2 Physiological demands of bowling

Research on the physiological demands of bowling is sparse with the only studies available being those which included some physiological measures when assessing other aspects of the game. One study found heart rates of between 154 and 158 $bt.min^{-1}$ during a 6-over fast bowling spell (Devlin et al., 2000). This was confirmed by Taliep et al. (2003) who found that heart rates during fast bowling ranged between 73% and 77% HR max. Burnett et al. (1995) reported peak heart rates of between 180 and 190 $bt.min^{-1}$ during a 12-over fast bowling spell. To the author's knowledge, no in-depth physiological studies have been done on bowlers suggesting a need to investigate these demands further. During a 6 to 8-over spell, bowling speed remains unchanged while accuracy has shown some non-significant variation (Portus et al., 2000; Devlin et al., 2000). In contrast, Taliep et al. (2003) found significant reductions in bowling speed after the 6^{th} over in a 12-over bowling spell and no change in accuracy.

5. Musculoskeletal demands of cricket

Noakes & Durandt (2000) speculate that the main cause of stress for cricket players is the repeated eccentric muscle damage resulting from multiple declarations that occur in batting and fast bowling. The stop-start nature of both sprinting between the wickets and fast bowling (during the 'run up' and delivery of the ball), contributes to early-onset fatigue indicators which, over time, results in a specific type of fatigue which negatively impacts performance and increases the risk of injury (Christie et al., 2011b). It has recently been shown that the physiological demands of batting in a one-day game are substantial and that players need to be well trained to optimally maintain this type of workload (Noakes & Durandt, 2000; Christie & King, 2008; Christie et al., 2008; Christie et al., 2011a

and b). With respect to bowling, although most of the research has focused on lower back injuries (Stretch et al., 2000), it is the view of Noakes & Durandt (2000), that the repeated eccentric actions during fast bowling are the real source of stress for fast bowlers and that this needs to be followed up and related to speed and accuracy of bowling as well as injury potential. Substantial muscle strength is needed to reduce muscle damage arising from these repeated actions (Thompson et al., 1999). The ability to cope with repeated eccentric loading such as during cricket may require substantial muscle strength in order to reduce the damage (Noakes & Durandt, 2000). Running research has shown that repeated eccentric actions produce a specific form of fatigue that requires substantial recovery time (Nicol et al., 19991). They alter muscle function particularly with respect to a reduction in elastic energy production which results in increased work during the push-off phase (Nicol et al., 1991). Recovery time from this damage can take up to 2 weeks post-marathon.

Although the research on eccentric load placed on cricketers is still in its infancy, a recent pilot study from our laboratory looked specifically at the strength decrements associated with repeated sprints between the wickets (Christie et al., 2011b). The protocol was exactly that of Christie et al. (2011a) but which assessed isokinetic (concentric and eccentric) strength changes.

		QUADRICEP DECREASE (%)		**HAMSTRING DECREASE (%)**	
Leg	**Speed (deg.s^{-1})**	**Concentric**	**Eccentric**	**Concentric**	**Eccentric**
Right	60	14.12	18.68	9.76	12.15
Left	60	7.53	6.07	8.79	13.36
Right	180	3.69	15.65	10.41	14.94
Left	180	7.58	6.66	11.19	9.33
	MEAN	**8.23**	**11.77**	**10.04**	**12.45**

Table 1. Representing the percentage decrease (%) in peak torque values.

Eccentric strength changes were greater than concentric changes (Table 1). Overall, the strength of the quadriceps decreased by 8.23% concentrically and 11.77% eccentrically while the strength of the hamstrings decreased by 10.04% concentrically and 12.45% eccentrically. This was evident in both legs and in both muscle groups (mean decrement of 11.77% and 12.45% in the quadriceps and hamstrings eccentric strength respectively). While concentric hamstring decrements ranged between 9.76% (Right leg at 60 deg.s^{-1}) and 11.19% (Left leg at 180 deg.s^{-1}) the range was much larger for the quadriceps concentrically. More specifically, there was a 14.12% decrement in concentric quadriceps strength at 60 deg.s^{-1} in the right leg and only a 3.69% in the same leg at 180 deg.s^{-1}.

As with the peak torque changes, there were similar decrements in work over time (Table 2). The greatest decrement in work was to the hamstring musculature eccentrically (decrement of 14.70%). This was followed by the eccentric work of the quadriceps muscle group

(11.13%). With respect to eccentric changes, although the hamstrings were affected similarly in both legs, the quadriceps showed greater decrements in the dominant, right leg and virtually no change in the non-dominant, left leg (Table 2).

		QUADRICEP DECREASE (%)		HAMSTRING DECREASE (%)	
Leg	**Speed ($deg.s^{-1}$)**	**Concentric**	**Eccentric**	**Concentric**	**Eccentric**
Right	60	16.34	21.53	9.65	15.73
Left	60	11.74	1.56	5.65	14.12
Right	180	3.98	14.99	12.73	17.91
Left	180	10.27	6.44	8.47	11.04
	MEAN	**10.58**	**11.13**	**9.12**	**14.70**

Table 2. Representing the percentage decrease (%) in peak work values.

Strength losses are considered reliable indicators of exercise-induced muscle damage (Warren et al., 1999) which are likely after repeated eccentric muscle actions. When strength losses occur, there is a much higher chance of muscular strain and joint instability. Further, this could impact performance such as reduced ability to accelerate and decelerate when running between the wickets or could lead to more errors, increasing susceptibility to injury (Rhanama et al., 2003). The greater eccentric strength decline of the hamstrings may be due to the greater requirement of the hamstrings to control running actions and for stabilizing the knee joint during foot contact with the ground. If this is the case, then it could lead to less control and lower stability of the knee and greater risk of injury (Rhanama et al., 2003).

5.1 Eccentric loading and fatigue

In their book 'Art and Science of Cricket', Woolmer & Noakes (2008) provide a comprehensive section on what they consider to be the main cause of cricketing fatigue. Basically, they propose that eccentric actions alter muscle recruitment over time resulting in the inability to store the energy of landing and recover energy for the push-off phase of the running stride which follows. The brain must then decide to either recruit more fibres to assist in the push-off phase in order to keep the same speed of running or reduce running speed in order to cope. As the bowling spell or batting innings progresses, the way in which the muscles are recruited will change because of the body's natural desire to protect the vital organs from catastrophic failure, referred to as the 'central governor' (Noakes et al., 2001). Despite this, the player must still produce the same result.

So, according to the central integrative model of exercise regulation (Figure 5), the subconscious brain is making these choices, and altering the way in which it recruits the muscles (St Clair Gibson & Noakes, 2004). It sets the number of motor units activated throughout the exercise bout (1). Sensory feedback from various physiological systems results in an appropriate adjustment in muscle recruitment (2). At the start of the bowling spell or batting innings, the subconscious brain informs the conscious brain (3) of increasing

neural effort and this is interpreted as an increased sensation of fatigue (4) which can then also further influence the subconscious (5). Basically, the subconscious influences the conscious brain with sensations of fatigue (commonly seen in ratings of perceived effort) so the bowler or batsmen alters speed in order to ensure they have enough reserve to complete the bowling spell and/or innings.

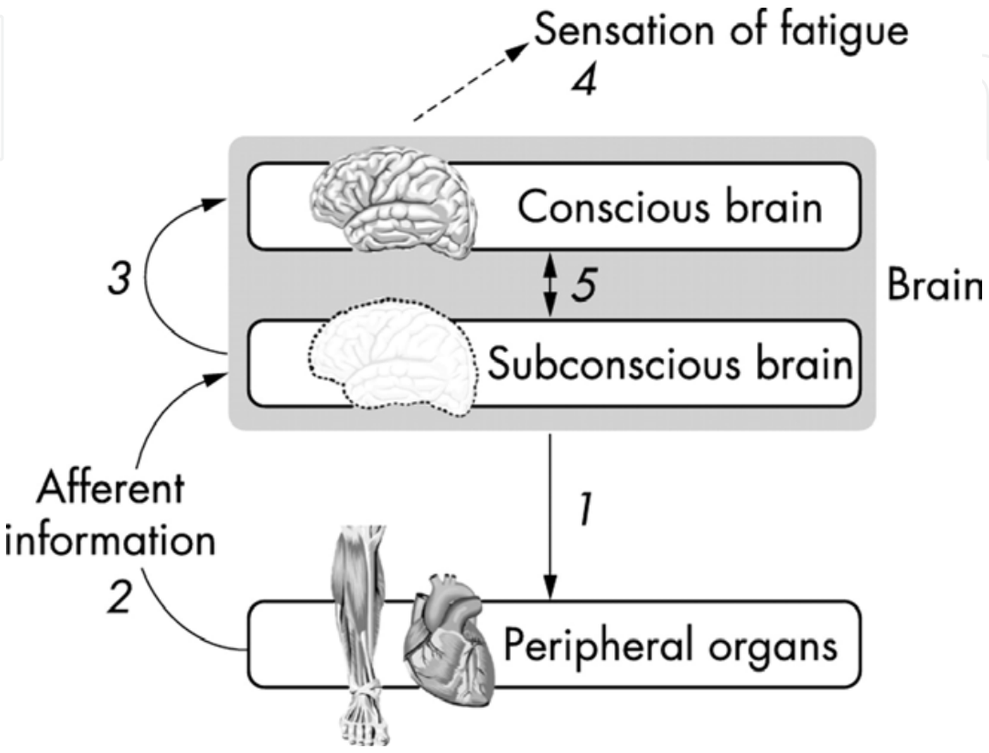


Fig. 5. The central integrative model of exercise regulation. (Taken from St Clair Gibson & Noakes TD, 2004).

If their theory is correct, then the main goal of training programmes should be on the development of eccentric training programmes to assist players in coping with this stress and hopefully reducing their risk of injury by delaying the onset of fatigue (Woolmer & Noakes, 2004).

6. Conclusion

Research on all aspects of the game of cricket is needed in order to better understand the demands being placed on players as well as to link these to fatigue indicators and injury risk. The sport has a long way to go in terms of linking science and practice evident in other sports such as football. Until more is understood of the demands of the game, training programmes will be merely based on trial and error and not grounded in science. This means that it is probable that players are not getting adequately prepared for play and as a result, are becoming injured more frequently. This is particularly the case for injuries which are more avoidable and linked to fatigue, such as sprains and strains. Further, there is a

need for more communication and cooperation between sports scientists involved in cricket research and coaches of the game to ensure mutual benefit. This chapter contends that the real source of stress for cricketers is the musculoskeletal demands and associated stressors and that research needs to consider linking appropriate eccentrically based training programmes with fatigue indicators, performance affects and injury risk reduction.

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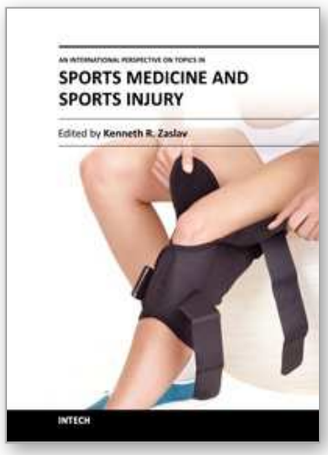
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For the past two decades, Sports Medicine has been a burgeoning science in the USA and Western Europe. Great strides have been made in understanding the basic physiology of exercise, energy consumption and the mechanisms of sports injury. Additionally, through advances in minimally invasive surgical treatment and physical rehabilitation, athletes have been returning to sports quicker and at higher levels after injury. This book contains new information from basic scientists on the physiology of exercise and sports performance, updates on medical diseases treated in athletes and excellent summaries of treatment options for common sports-related injuries to the skeletal system.

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