Movement patterns in cricket vary by both position and game format

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Movement patterns in cricket vary by both position and game format

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Abstract

We compared the movement patterns of cricketers in different playing positions across three formats of cricket (Twenty20, One Day, multi-day matches). Cricket Australia Centre of Excellence cricketers (n = 42) from five positions (batting, fast bowling, spin bowling, wicketkeeping, and fielding) had their movement patterns (walk, jog, run, stride, and sprint) quantified by global positioning system (GPS) technology over two seasons. Marked differences in movement patterns were evident between positions and game formats, with fast bowlers undertaking the greatest workload of any position in cricket. Fast bowlers sprinted twice as often, covered over three times the distance sprinting, with much smaller work-to-recovery ratios than other positions. Fast bowlers during multi-day matches covered 22.6 ± 4.0 km (mean ± s) total distance in a day (1.4 ± 0.9 km in sprinting). In comparison, wicketkeepers rarely sprinted, despite still covering a daily total distance of 16.6 ± 2.1 km. Overall, One Day and Twenty20 cricket required *50 to 100% more sprinting per hour than multi-day matches. However, multi-day cricket’s longer duration resulted in 16–130% more sprinting per day. In summary, the shorter formats (Twenty20 and One Day) are more intensive per unit of time, but multi-day cricket has a greater overall physical load.

Keywords: Batting, bowling, fielding, limited overs, Twenty20

Introduction

Contemporary conditioning programmes are based on detailed knowledge of a sport’s movement patterns and physiological demands. Many sports, including Australian football (Dawson et al., 2004), basketball (Bishop & Wright, 2006), field-hockey (Spencer et al., 2004), rugby (Deutsch, Kearney, & Rehrer, 2007; Duthie, Pyne, & Hooper, 2005), football (Bangsbo Mohr, & Krstrup, 2006), Gaelic football (King & O’Donoghue, 2003), and water polo (D’Auria & Gabbett, 2008), have been studied using time–motion analysis to describe their physical demands. Cricket is unique in that three different game formats, namely Twenty20, One Day, and multi-day (Test and first-class) cricket, are played by elite players. To date, there are no comprehensive cricket time–motion studies accounting for both positional differences and game format.

Two preliminary time–motion studies have been conducted separately on first-class (county) fielding and international (Test and One Day) batting. Rudkin and O’Donoghue (2008) used real-time computerized time–motion analysis to observe 27 fielders for 10 overs. Extrapolating the data using prior electronically timed 15-m speed trials, the authors estimated that fielders covered ∼15.5 km in a day (3 × 2 h sessions). Duffield and Drinkwater (2008) used video recordings to compare century-scoring batsmen from One Day and Test cricket. The authors reported that similar proportions of time (One Day: 94%; Test: 96%) were spent in low-intensity (standing and walking) activity. However, because a Test match century took 37% longer to complete than a One Day International century, there were much longer recovery bouts between high-intensity efforts in Test cricket. While this study categorized movement descriptors into component parts (standing, walking, jogging, striding, sprinting, playing a shot, and lateral motion), the authors only reported temporal data with no estimates of the true distances covered.

Based on game descriptors, Noakes and Durandt (2000) described how in 1955 Fletcher calculated that Test batsmen covered less than 520 m h⁻¹.

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energy expenditure (650 kJ h\(^{-1}\)) slightly above that achieved when standing. Perhaps unfairly, Fletcher included time spent sitting watching the game in these calculations, therefore under-representing playing energy expenditure. Recent simulations of One Day cricket (Christie, Todd, & King, 2008) have estimated much higher energy demands of batsmen (i.e. 2536 kJ h\(^{-1}\)). Moreover, in their analysis of first-class fielding in the United Kingdom, Rudkin and O’Donoghue (2008) concluded that cricket is physically undemanding. Fletcher’s work may have reflected the game and fielding demands in the 1950s, while Rudkin and O’Donoghue’s work characterizes the current first-class fielding requirements in the United Kingdom. Together, these assertions reinforce the historical and contemporary perception that cricket is a physically undemanding sport. However, it is also possible, as shown by Christie et al. (2008), that these findings have underestimated the physiological demands of cricket.

Traditionally, time–motion studies have been conducted in real-time with pen, paper, and stopwatch/computer (notational) or post-game processing using video recordings with or without customized computer analysis (digitizing). Today, global positioning system (GPS) player tracking technology provides a more convenient, less time-consuming, and practically superior method for data collection (MacLeod, Morris, Nevill, & Sunderland, 2009; Townshend, Worringham, & Stewart, 2008). Data collected in time–motion studies help to develop knowledge of the positional differences in workload with different game formats. This information allows conditioning coaches to prescribe more game-specific training programmes. Therefore, the aim of this study was to quantify the movement patterns undertaken by players in different positions and formats of cricket.

**Methods**

**Participants**

Forty-two Cricket Australia Centre of Excellence male cricketers (age 22.1 ± 2.8 years, height 1.81 ± 0.08 m, mass 84.3 ± 8.7 kg, sum of seven skinfolds 66.6 ± 20.9 mm; mean ± s) provided informed consent and volunteered to participate in the study. Data were collected from 24 Tour games (7 × Twenty20, 16 × One Day, and 1 × three-day game). The opposition for these games included National “A” teams from New Zealand, South Africa, and India; first-class State teams from Australia (Tasmania) and India (Karnataka); and the Bangladesh and Australian National teams.

**Experimental procedures**

All participating players were fitted with a Mini-maxX (Catapult Innovations, Melbourne, Australia) GPS (5 Hz) unit. The standard error of the estimate (validity) of distance for walking to striding for these units ranged from 0.4 to 3.8%, while the estimate of reliability ranged from 0.3 to 2.9%. For sprinting 20 m, the mean typical error of validity and reliability was 22% (Petersen, Pyne, Portus, & Dawson, 2009).

Using an elasticized shoulder harness, the GPS unit was positioned to sit between the scapulae of the player at the base of the cervical spine. The GPS unit was activated and GPS satellite lock established for at least 15 min before the player took to the field in line with the manufacturer’s recommendations. After each session, the game movement data were downloaded using Logan Plus 4.0 software (Catapult Innovations, Melbourne, Australia) for analysis.

Players were classified as either a bowler or fielder in a particular fielding innings depending on whether they bowled or not. All data was recorded during a fielding innings, including bowling and fielding activity. Fast bowlers performed 4 ± 1 and 7 ± 2 overs bowling per innings for Twenty20 and One Day formats respectively, while in multi-day cricket they bowled 4 ± 2 overs per 2-h session. Twenty20 bowlers and players not bowling (excluding the wicketkeeper) were classified as fielders. It was not possible to analyse the fielder classification further (e.g. close infielders such as a slip, or outfielders such as deep cover, fine leg or third man) due to the frequent and often subtle position changes that occur during the innings. Each player was classified into the following positional or player type: fast bowler, spin bowler, wicketkeeper, fielder or batsman.

Fifteen players opted to wear a heart rate monitor (Polar, Finland) in Twenty20 and/or One Day games (Twenty20: 16 batting, 10 fast bowling, 7 fielding, 3 spin bowling, and 3 wicketkeeping files; One Day: 5 batting and 5 fielding files). After each session, the heart rate data were downloaded using Polar Precision Performance 4.03 software (Polar Electro, Finland) and the maximal and mean heart rates for these files were then determined.

**Movement pattern analyses**

The following movement categories were established:

- standing/walking 0–2.00 m s\(^{-1}\) (0–7.2 km h\(^{-1}\));
- jogging 2.01–3.50 m s\(^{-1}\) (7.2–12.6 km h\(^{-1}\)).
• running 3.51–4.00 m·s\(^{-1}\) (12.6–14.4 km·h\(^{-1}\));
• striding 4.01 – 5.00 m·s\(^{-1}\) (14.4–18 km·h\(^{-1}\));
• sprinting ≥5.01 m·s\(^{-1}\) (>18 km·h\(^{-1}\)).

Logan Plus 4.0 software (Catapult Innovations, Melbourne, Australia) was used to estimate the cumulative distance covered in each of these movement categories.

In a further level of classification, standing, walking, and jogging were considered “low-intensity efforts”, while running, striding, and sprinting were considered “high-intensity efforts”. The ratio of time spent in high- versus low-intensity activity provided a surrogate measure of the work-to-recovery ratio. The numbers and distances (mean, maximum) of sprinting efforts were reported by the Logan Plus software 4.0 (Catapult Innovations, Melbourne, Australia). Adopting a similar approach to Spencer et al. (2004), an episode of repeat sprint activity was defined as a cluster of three or more sprints with less than 60 s recovery between consecutive efforts.

Statistical analysis

Descriptive statistics (mean ± s) were used to characterize the central tendency of the data. To facilitate direct comparison between game formats, player data files during the fielding innings were scaled to movements completed per hour of play. Batting files were also scaled to a 1-h innings, and innings shorter than 20 min were excluded from the analysis.

We used magnitude-based inferences to analyse the time–motion measures (Batterham & Hopkins, 2006). The effect size statistic was generated to characterize the magnitude of difference between positions across the three formats of the game. Briefly, the criteria for interpreting effect sizes were: <0.2 trivial, 0.2–0.6 small, 0.6–1.2 moderate, 1.2–2.0 large, and > 2.0 very large (Hopkins, 2004). Precision of estimation was indicated with a 90% confidence interval (90% CI). The coefficient of variation (CV) expressed as a percentage (%CV) was used to characterize the amount of variability in the time–motion data.

Results

Positional movement patterns and physiological variables

The mean distance covered per hour by players in each position and format of the game is illustrated in Figure 1. Fast bowlers covered the greatest total distance in all game formats. Extrapolating the data to a full 3.5 h of a One Day innings, fast bowlers covered 13.4 ± 0.7 km (mean ± 90% CI) in total distance. In comparison, fast bowlers covered 5.5 ± 0.4 km in an 80-min Twenty20 innings and 22.6 ± 2.1 km in a full day of play (3 × 2 h sessions) of multi-day cricket. Table I summarizes movement categories contributing to this total distance. Fast bowlers covered the greatest distance in striding and sprinting across all formats of the game. During a full One Day innings, fast bowlers covered 1.1 km at sprinting intensities. In comparison, the wicketkeeper travelled the least total distance in a One Day innings, averaging only 9.5 km and covering only 0.1 km at sprinting intensities. However, wicketkeepers covered a greater distance per hour in high-intensity efforts (running, striding, sprinting) in Twenty20 (344 m) than One Day (240 m) or multi-day (109 m) cricket. Batsmen in an entire One Day innings covered 8.7 ± 0.6 km (mean ± 90% CI), with 0.5 km covered at sprinting intensity. Batting for a full Twenty20 innings (80 min) batsmen covered 3.5 ± 0.2 km, while in the unlikely event a batsman bats all day in a multi-day match, an estimated 13.0 ± 2.0 km would be covered. This workload is in addition to the distances a batsman covered during the fielding innings.

Across all game formats, fast bowlers had the lowest work-to-recovery ratio and the highest number of sprints (Table II). During Twenty20 innings, fast bowlers met the criteria for repeat sprint activity on 3.3 ± 1.5 occasions with a mean 4.8 ± 1.4 sprints per bout. In comparison, during One Day and multi-day innings, fast bowlers performed 6.2 ± 2.9 and 5.5 ± 4.0 repeat sprint bouts, with a mean 5.0 ± 1.4 and 4.9 ± 0.7 sprints per bout, for One Day and multi-day cricket respectively. The number of repeat sprint bouts generally matched the number of overs.
Table I. Movement category distances by playing position and game format (mean ± s).

<table>
<thead>
<tr>
<th>Game format and playing position</th>
<th>Walking (0–2.00 m · s⁻¹)</th>
<th>Jogging (2.01–3.50 m · s⁻¹)</th>
<th>Running (3.51–4.00 m · s⁻¹)</th>
<th>Striding (4.01–5.00 m · s⁻¹)</th>
<th>Sprinting (≥5.01 m · s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Twenty20</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 26)</td>
<td>1638 ± 352</td>
<td>332 ± 103</td>
<td>97 ± 35</td>
<td>187 ± 70</td>
<td>175 ± 97</td>
</tr>
<tr>
<td>Fast bowlers (n = 18)</td>
<td>2634 ± 268</td>
<td>718 ± 276</td>
<td>164 ± 76</td>
<td>249 ± 121</td>
<td>406 ± 230</td>
</tr>
<tr>
<td>Fielders (n = 26)</td>
<td>2242 ± 448</td>
<td>737 ± 219</td>
<td>157 ± 71</td>
<td>182 ± 101</td>
<td>129 ± 91</td>
</tr>
<tr>
<td>Spin bowlers (n = 10)</td>
<td>2317 ± 282</td>
<td>678 ± 210</td>
<td>107 ± 40</td>
<td>109 ± 53</td>
<td>81 ± 55</td>
</tr>
<tr>
<td>Wicketkeeper (n = 3)</td>
<td>1587 ± 139</td>
<td>552 ± 166</td>
<td>138 ± 90</td>
<td>147 ± 77</td>
<td>59 ± 23</td>
</tr>
<tr>
<td><strong>One Day</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 36)</td>
<td>1808 ± 400</td>
<td>279 ± 119</td>
<td>86 ± 37</td>
<td>154 ± 70</td>
<td>149 ± 94</td>
</tr>
<tr>
<td>Fast bowlers (n = 24)</td>
<td>2520 ± 362</td>
<td>618 ± 217</td>
<td>157 ± 58</td>
<td>220 ± 81</td>
<td>316 ± 121</td>
</tr>
<tr>
<td>Fielders (n = 52)</td>
<td>2117 ± 374</td>
<td>640 ± 193</td>
<td>119 ± 46</td>
<td>124 ± 59</td>
<td>81 ± 51</td>
</tr>
<tr>
<td>Spin bowlers (n = 8)</td>
<td>2251 ± 239</td>
<td>621 ± 154</td>
<td>116 ± 43</td>
<td>120 ± 63</td>
<td>58 ± 37</td>
</tr>
<tr>
<td>Wicketkeeper (n = 6)</td>
<td>1913 ± 196</td>
<td>558 ± 104</td>
<td>109 ± 16</td>
<td>97 ± 29</td>
<td>34 ± 21</td>
</tr>
<tr>
<td><strong>Multi-day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 9)</td>
<td>1604 ± 438</td>
<td>200 ± 90</td>
<td>67 ± 18</td>
<td>107 ± 33</td>
<td>86 ± 28</td>
</tr>
<tr>
<td>Fast bowlers (n = 10)</td>
<td>2512 ± 258</td>
<td>614 ± 173</td>
<td>185 ± 89</td>
<td>233 ± 133</td>
<td>230 ± 149</td>
</tr>
<tr>
<td>Fielders (n = 20)</td>
<td>1773 ± 339</td>
<td>480 ± 160</td>
<td>88 ± 43</td>
<td>83 ± 55</td>
<td>52 ± 33</td>
</tr>
<tr>
<td>Spin bowlers (n = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wicketkeeper (n = 4)</td>
<td>2135 ± 151</td>
<td>523 ± 214</td>
<td>51 ± 18</td>
<td>35 ± 24</td>
<td>23 ± 30</td>
</tr>
</tbody>
</table>

¹Small, ²moderate, ³large, and ⁴very large magnitudes of difference within position between Twenty20 and One Day cricket. ⁵Small, ⁶moderate, ⁷large, and ⁸very large magnitudes of difference within position between Twenty20 and multi-day cricket. ⁹Small, ¹moderate, ¹¹large, and ¹²very large magnitudes of difference within position between One Day and multi-day cricket.

Table II. Movement variables by playing position and game format (mean ± s).

<table>
<thead>
<tr>
<th>Game format and playing position</th>
<th>No. of sprints per hour</th>
<th>Mean sprint Distance (m)</th>
<th>Maximum sprint distance (m)</th>
<th>No. of efforts per hour</th>
<th>Recovery ratio (1 : x)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Twenty20</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 26)</td>
<td>15 ± 9b</td>
<td>13 ± 4³</td>
<td>19 ± 6¹</td>
<td>45 ± 16²,⁴</td>
<td>38 ± 13³,⁶</td>
</tr>
<tr>
<td>Fast bowlers (n = 18)</td>
<td>23 ± 10¹,⁷</td>
<td>17 ± 4³</td>
<td>35 ± 13²,⁴</td>
<td>61 ± 25</td>
<td>25 ± 18</td>
</tr>
<tr>
<td>Fielders (n = 26)</td>
<td>8 ± 5²</td>
<td>15 ± 4³</td>
<td>31 ± 14³</td>
<td>42 ± 20²,⁴</td>
<td>43 ± 28²,⁴</td>
</tr>
<tr>
<td>Spin bowlers (n = 10)</td>
<td>5 ± 4</td>
<td>16 ± 5³</td>
<td>24 ± 10⁷</td>
<td>25 ± 12³</td>
<td>63 ± 36³</td>
</tr>
<tr>
<td>Wicketkeeper (n = 3)</td>
<td>5 ± 2⁴</td>
<td>13 ± 0⁴</td>
<td>14 ± 6³</td>
<td>30 ± 18⁷</td>
<td>51 ± 21⁷,⁹</td>
</tr>
<tr>
<td><strong>One Day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 36)</td>
<td>13 ± 9³</td>
<td>11 ± 3⁶</td>
<td>21 ± 11</td>
<td>39 ± 16³</td>
<td>50 ± 21³</td>
</tr>
<tr>
<td>Fast bowlers (n = 24)</td>
<td>18 ± 5³</td>
<td>18 ± 3⁶</td>
<td>46 ± 12³</td>
<td>54 ± 14³</td>
<td>25 ± 7²</td>
</tr>
<tr>
<td>Fielders (n = 52)</td>
<td>5 ± 3³</td>
<td>15 ± 4³</td>
<td>34 ± 14³</td>
<td>27 ± 11³</td>
<td>62 ± 41⁴</td>
</tr>
<tr>
<td>Spin bowlers (n = 8)</td>
<td>4 ± 1³</td>
<td>15 ± 5³</td>
<td>33 ± 13³</td>
<td>29 ± 10³</td>
<td>54 ± 16⁴</td>
</tr>
<tr>
<td>Wicketkeeper (n = 6)</td>
<td>2 ± 1³</td>
<td>16 ± 9⁴</td>
<td>22 ± 11²</td>
<td>23 ± 4⁴</td>
<td>64 ± 18⁷</td>
</tr>
<tr>
<td><strong>Multi-day</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batsmen (n = 9)</td>
<td>8 ± 3⁴</td>
<td>13 ± 7³</td>
<td>21 ± 8³</td>
<td>28 ± 6³</td>
<td>61 ± 10</td>
</tr>
<tr>
<td>Fast bowlers (n = 10)</td>
<td>17 ± 11⁵</td>
<td>13 ± 1³</td>
<td>28 ± 5³</td>
<td>56 ± 29</td>
<td>38 ± 31</td>
</tr>
<tr>
<td>Fielders (n = 20)</td>
<td>3 ± 2³</td>
<td>16 ± 7³</td>
<td>26 ± 14³</td>
<td>19 ± 8³</td>
<td>90 ± 52</td>
</tr>
<tr>
<td>Spin bowlers (n = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wicketkeeper (n = 4)</td>
<td>2 ± 4³</td>
<td>11 ± 19²</td>
<td>12 ± 9³</td>
<td>12 ± 6³</td>
<td>167 ± 73</td>
</tr>
</tbody>
</table>

Note: A sprint is defined as movement above 5 m · s⁻¹ for at least 1 s.

¹Small, ²moderate, ³large, and ⁴very large magnitudes of difference within position between Twenty20 and One Day cricket. ⁵Small, ⁶moderate, ⁷large, and ⁸very large magnitudes of difference within position between Twenty20 and multi-day cricket. ⁹Small, ¹moderate, ¹¹large, and ¹²very large magnitudes of difference within position between One Day and multi-day cricket.

bowled in Twenty20 (4 ± 1 overs), One Day (7 ± 2 overs), and multi-day (4 ± 2 overs) cricket. No other positional group had more than one repeat sprint bout per innings.

Heart rate data were only collected from a small subset of the players. Based on these data, Twenty20 batsmen had a higher mean heart rate (149 ± 17 beats · min⁻¹) than batsmen playing One Day (144 ± 13 beats · min⁻¹) cricket. Fast bowlers playing Twenty20 cricket had a lower mean heart rate than (133 ± 12 vs. 149 ± 17 beats · min⁻¹), but a similar maximal heart rate to (181 ± 10 vs. 181 ± 14 beats · min⁻¹), Twenty20 batsmen (Figure 2).
Differences in game formats

The difference in total distance covered per hour between game formats is illustrated in Figure 1. Generally, cricketers covered more distance per hour in Twenty20 than One Day cricket: fast bowlers covered an additional 340 m/h, fielders 370 m/h, and spin bowlers 190 m/h respectively. In contrast, wicketkeepers covered 230 m/h less distance in Twenty20. Comparing Twenty20 with multi-day cricket, fast bowlers covered an additional 400 m/h, fielders 970 m/h, and batsmen 370 m/h in Twenty20. However, wicketkeepers covered less distance (280 m/h) in Twenty20 than multi-day cricket. Finally, comparing One Day with multi-day cricket, batsmen (410 m/h) and fielders (600 m/h) covered moderately more distance in One Day cricket.

Variability of time–motion and physiological variables

The number of sprints, mean sprint distance, and total distance covered sprinting were the three most variable measures. The coefficient of variation across positions and game formats ranged from 25 to 200%, from 0 to 173%, and from 33 to 130% for number of sprints, mean sprint distance, and distance covered sprinting, respectively. In contrast, wicketkeepers covered 230 m/h less distance in Twenty20. Comparing Twenty20 with multi-day cricket, fast bowlers covered an additional 400 m/h, fielders 970 m/h, and batsmen 370 m/h in Twenty20. However, wicketkeepers covered less distance (280 m/h) in Twenty20 than multi-day cricket. Finally, comparing One Day with multi-day cricket, batsmen (410 m/h) and fielders (600 m/h) covered moderately more distance in One Day cricket.

Batsmen. Batsmen performed at a similar intensity during Twenty20 and One Day games, covering a total distance of \(\sim 2.6 \text{ km} \cdot \text{h}^{-1}\), yet during multi-day games they covered 0.4 km less distance per hour (85% of the distance covered in the shorter formats). The volume of work undertaken while batting is directly related to the time a batsman remains at the crease. Theoretically, a batsman that can successfully bat an entire innings will cover \(\sim 13.0, 8.7, \text{ and } 3.5 \text{ km}\) in multi-day (6 h), One Day, and Twenty20 cricket respectively.

The work-to-recovery ratio of batsmen during One Day games (1 : 50) in the present study is very similar to that reported by Duffield and Drinkwater (2008) for international One Day batsmen (1 : 47). Additionally, the mean heart rate (144 ± 13 beats·min\(^{-1}\)) of One Day batsmen in the present study is almost identical to that reported by Christie et al. (2008) in a study simulating the physiological
demands of international One Day batsmen. These results suggest that batting demands may be similar across performance levels.

**Fast bowlers.** Of all positions, fast bowlers operated with the greatest intensity across all formats of the game. Compared with other positions, fast bowlers covered 20–80% greater distance, covered 1.8- to 7-fold greater distance during high-intensity movement patterns (sprinting and striding), sprinted more often (1.4–8 times as frequently), and had at least 35% less recovery time between high-intensity efforts. Additionally, the use of the criteria for repeat sprint activity (defined as a minimum of three sprints, with mean recovery duration between sprints of less than 60 s) revealed that only fast bowlers undertook sprinting in clusters. The analysis demonstrates repeat sprint bouts occur during bowling spells, but they can also occur when fast bowlers are performing their fielding duties in between bowling overs. The number of clusters and sprints per cluster bout appears to reflect the bowling spells undertaken in the different game formats (maximum of four 6-ball overs in Twenty20; maximum of ten 6-ball overs in One Day). However, occasionally, the between-over rest period was interrupted with a fielding sprint effort that resulted in two successive overs contributing to the number of sprints in a cluster.

Twenty20 was 22% and 43% more intensive for fast bowlers than One Day and multi-day cricket respectively, in terms of the hourly sprint distance. Yet, the cumulative sprinting in Twenty20 and One Day games was only 39 and 80% of the daily (6 h) 1.4 km sprinted during multi-day cricket.

Twenty20 required 340 and 400 m greater distance per hour from fast bowlers than One Day and multi-day cricket respectively. Yet in absolute terms, fast bowlers covered a total distance of ~22.6, ~13.4, and 5.5 km in multi-day (6 h), One Day, and Twenty/20 innings respectively. Consequently, Twenty20 and One Day cricket required only 24 and 59% of the total distance covered in multi-day cricket.

Comparing fast bowlers’ mean heart rates (133 ± 12 beats·min⁻¹) with those of batsmen (149 ± 17 beats·min⁻¹) in Twenty20, the fast bowlers’ lower mean heart rate may relate to the extended periods that Twenty20 fast bowlers are in the field (77 ± 17 min) compared with the Twenty20 batsmen’s comparably shorter (40 ± 14 min) individual (batting) innings. Both fast bowlers (181 ± 10 beats·min⁻¹) and batsmen (181 ± 14 beats·min⁻¹) in Twenty20 had similar maximal heart rates, which indicates the number of sprints per hour (23 ± 10 vs. 15 ± 9) combined with the respective recovery ratios (1 : 25 vs. 1 : 15) provided sufficient stress to reach similar high heart rates.

**Fielders.** The intensity of fielding is greatest in Twenty20 cricket, in that One Day and multi-day cricket require only 89 and 72% of the Twenty/20 total hourly distance respectively. It is also important to consider the volume of work undertaken in each format of cricket by taking into account the absolute duration of each type of innings. We estimate that fielders covered ~15 km in 6 h of fielding during a multi-day game, consistent with the estimates of Rudkin and O’Donoghue (2008) that fielders covered 15.5 km in English County cricket. In comparison, fielders in Twenty20 and One Day cricket covered ~4.6 and ~10.8 km in their respective (80 and 210 min) innings.

**Spin bowlers.** Unfortunately, no spin bowlers wore the GPS devices in multi-day cricket, thus comparisons can only be made between the One Day and Twenty20 game formats. Spin bowlers in Twenty20 and One Day cricket performed a similar amount of sprinting (<100 m·h⁻¹) and covered a similar hourly distance (3.3 and 3.1 km respectively). However, when the duration of the different game formats is taken into account, spin bowlers covered 11.0 and 4.4 km in a One Day and Twenty20 innings respectively.

**Wicketkeepers.** Surprisingly, wicketkeepers covered more distance per hour (280 and 50 m more) in multi-day than Twenty20 and One Day cricket respectively. However, a greater proportion of total distance covered in the shorter game versions was at higher intensities. Compared with multi-day cricket, wicketkeepers covered 230 and 130 m·h⁻¹ more distance at high intensity (running, striding, sprinting) during the shorter game formats of Twenty20 and One Day respectively. Consequently, wicketkeepers enjoyed a substantially longer recovery time between high-intensity efforts in multi-day (167 s) compared with One Day (64 s) and Twenty20 (51 s) cricket. Nevertheless, in absolute terms, wicketkeepers covered a total distance of ~16.6, ~9.5, and ~3.3 km in multi-day (6 h), One Day, and Twenty/20 innings respectively.

**Summary.** In general, across positions the recovery time between high-intensity efforts is almost a third longer in One Day and twice as long in multi-day cricket compared with Twenty20. Our results indicate that differences in physiological demand exist by position and game format. Further work needs to be undertaken to compare the progression pathway of positional demands from first-class to international cricket.
Application of motion analysis data

Conducting a time–motion analysis is only the first step in designing more effective sport- and position-specific conditioning programmes. Interpreting and utilizing the data from time–motion studies is a critical step in prescribing an athlete’s training programme. Early attempts in field hockey and netball (Huey, Morrow, & O’Donoghue, 2001; O’Donoghue & Cassidy, 2002) to apply time–motion data failed to obtain fitness improvements over and above traditional training. However, for Gaelic Football, King and O’Donoghue (2003) demonstrated that match-specific training (varying burst length and recovery periods to reflect those used in competition) based on GPS time–motion data incorporating progression and overload was a more effective conditioning method than traditional fitness training. Future studies should investigate whether time–motion based training (incorporating set work-to-recovery ratios and frequency of sprints) is more effective than traditional cricket training (non-specific fitness training combined with long net batting and bowling sessions) in improving cricket-specific fitness.

Most team sport athletes spend more time involved in training than in competition. However, this may not apply to elite cricketers. For example, Australian national team players had a total of 90 matches (2 × Twenty20, 18 × One Day, and 14 × Test matches) possible competitive playing days in the 2008 calendar year. This number is likely to increase with newer franchise-based competitions (e.g. Indian Premier League, Indian Cricket League) extending the playing opportunities for international players. With a shorter off-season to improve fitness, in-season fitness maintenance becomes even more important. Contemporary in-season training practices combined with game demands are not generally sufficient to maintain endurance fitness (9% decrement) through a first-class season (Petersen, Pyne, Portus, & Dawson, 2008). The unpredictable nature of games usually dictates that a player will not train on a match day, thus in-season conditioning work must be undertaken primarily on non-playing days and scheduled around travelling requirements. Conditioning coaches may use detailed information on the game-to-game demands of players to balance conditioning and recovery activities to minimize fitness decrements, while maximizing physical performance during games.

Conclusion

The demands of cricket varied substantially by both player position and game format. Fast bowlers had the greatest workloads across all formats of the game, and Twenty20 cricket was more intense for all positions. While the intensity of the game increases for all positions with the shorter game formats, the longer duration of multi-day cricket elicits a much larger overall physical load. The movement data of this study indicate that cricket is a highly intermittent short sprint sport with a substantial base of low-intensity activity. This study provides detailed match demand values for cricket conditioning coaches, and careful application of these data should enhance the development and modification of position-specific conditioning programmes.

References


