Title: Battlezone**:** An examination of the physiological responses, movement demands and reproducibility of small-sided cricket games

Running Title: Physiological and physical demands of Battlezone

Key Words: Cricket, small-sided games, movement analysis, heart rate, RPE

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Abstract

As cricket training typically involves separate skill and conditioning sessions, this study reported on the movement demands, physiological responses and reproducibility of the demands of small-sided cricket games. Thirteen amateur, male cricket players (age: 22.8 ± 3.5 yr, height: 1.78 ± 0.06 m, body mass: 78.6 ± 7.1 kg) completed two sessions of a generic small-sided cricket game, termed Battlezone; consisting of six repeat 8 over bouts. Heart rate and movement demands were continuously recorded, whilst blood lactate concentration and perceived exertion were recorded after each respective bout. Batsmen covered the greatest distance (1147 ± 175 m) and demonstrated the greatest mean movement speed (63 ± 9 $m \cdot min^{-1}$) during each bout. The majority of time (65-86%) was spent with a heart rate of between 51-85%HR_{max} and a blood lactate concentration of 1.1-2.0 $mmol.L^{-1}$. Rating of perceived exertion ranged between 4.2-6.0. Movement demands and physiological responses did not differ between standardised sessions within respective playing positions ($p>0.05$). The reliability for the majority of movement demands and physiological responses were moderate to high (CV: 5-17%; ICC: 0.48-1.00) within all playing positions. These results suggest that the physiological responses and movement characteristics of a generic small-sided cricket games were consistent between sessions within respective playing positions.

Introduction

Replication of competitive match demands is often viewed as an appropriate and beneficial training stimulus (Gabbett, Jenkins & Abernethy, 2009; Gabbett, 2008). Accordingly, small-sided games are a popular training method used to replicate technical skills and tactical awareness, whilst also representing the physiological demands typical of a competitive match (Gabbett et al., 2009). Further, the periodised use of small-sided games may include modifying constraints such as the area of a playing field, player numbers or match rules to alter the physiological, physical and technical demands (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). For football related sports, small-sided games appear equally effective at improving physical fitness and match performance when compared to traditional conditioning and skill-based training methods (Dellal et al., 2008; Impellizzeri et al., 2006). Previous research has also reported that these responses are reproducible both between and within training sessions in football (Hill-Haas, Rowsell, Coutts & Dawson, 2008), suggesting a training mode that is match-specific, yet also provides a sufficient physiological training stimulus.

Recently, a small-sided games approach to cricket training has been developed and termed ‘Battlezone’ (Renshaw, Chappell, Fitzgerald, Davison & McFadyen, 2010). Renshaw et al. (2010) proposed that Battlezone allows players to acquire cricket-specific skills in an intensive match-simulation environment. Such a training environment may facilitate a greater transference of learnt skills into match play (Renshaw et al., 2010). Typically, cricket training places a greater emphasis on technical abilities rather than physical or physiological demands (Bartlett, 2003; Stretch, Bartlett & Davids, 2000). As such, training practices historically used in cricket have reflected this preference of technical proficiency (Woolmer, Noakes & Moffett, 2009). Cricket training has traditionally involved

structured net sessions combined with separate fielding drills and structured conditioning sessions that have not attempted to replicate the demands of specific match conditions (Pyke & Davis, 2010). Recently, Petersen, Pyne, Dawson, Portus and Kellett (2010) identified the large percentage of low-intensity activity interspersed with intermittent, short sprints associated with cricket match-play, regardless of the playing format. In the same study, it was also established that the demands of cricket player's varies between each playing position, with fast bowlers completing the greatest workload (Petersen et al., 2010). Furthermore, as the length of the match decreased, the playing intensity of the players tended to increase (Petersen et al., 2010).

Given there has been an increase in the number of shorter format cricket matches, the training practices adopted by cricket teams may not have evolved with the physical demands of cricket match-play (Fletcher, 1955; Petersen et al., 2010). Other sports such as soccer and rugby league have employed small-sided games to provide a training environment that is capable of simulating externally valid technical and tactical scenarios, whilst applying physical demands representative of competitive match-play loads. However, as the physical and physiological demands of Battlezone remains unknown, it is difficult to suggest Battlezone training can provide an appropriate physiological stimulus to replicate match demands. Therefore, the primary aim of this study was to report on the physical and physiological demands of Battlezone in cricket players. Secondly, the research also aimed to quantify the reproducibility of these demands between repeated generic Battlezone sessions.

Methods

Participants

Thirteen amateur, male cricket players (age: 22.8 ± 3.5 yr, height: 1.78 ± 0.06 m, body mass: 78.6 ± 7.1 kg) were recruited. All participants were playing first or second grade within a suburban competition and performed two cricket-specific training sessions per week. Participants gave written and verbal informed consent prior to any testing. The research was approved by the University of Newcastle Human Research Ethics Committee.

Procedure

Following an initial familiarisation session, all participants completed two Battlezone sessions that were separated by seven days on a prepared, turf cricket pitch in similar environmental conditions (21.1 ± 1.3ºC; 91.5 ± 6.4% relative humidity). A 0.8 m high cricket net was placed around the 30 yd inner circle line of a standard cricket field (International Cricket Council, 2009). Each Battlezone session consisted of six bouts in total, of which, each bout included 8 overs lasting 18 ± 2 min. Bouts were separated by 5 min of passive rest. Participants were classified as a batsman, medium-fast bowler, spin bowler, fielder or wicketkeeper according to their role during each bout. A total of eight participants were on the field at any one time.

One bout of Battlezone required two bowlers to complete four alternating overs to a batting pair. Fielders were positioned at backward point, cover, mid-wicket and wicketkeeper. When not bowling, bowlers were situated at mid-off, but still classified as bowlers (see Figure 1). All participants batted during at least one bout, with two participants batting during two non-consecutive bouts. Three bowlers bowled a minimum of two spells (8 overs in total) with a further two bowlers completing 4 extra overs. Two wicketkeepers were used throughout

each session; each keeping for 3 bouts in total. Those not taking part in an 8 over bout were allowed to rest outside of the Battlezone playing field. The sequence in which all participants performed the respective Battlezone bouts was identical between the two data collection periods.

*****INSERT FIGURE 1 AROUND HERE*****

The Battlezone session chosen represented a scenario typically observed within the inner circle of the middle section of a One-Day cricket match. All Battlezone sessions were completed under the rules governing cricket match play (International Cricket Council, 2009). Batsmen were instructed to score as many runs as possible, and were encouraged to hit the ball along the ground as often as possible and not over the net as per developing match specific technique. If dismissed, batsmen changed ends and play continued. Bowlers were instructed to restrict the amount of runs scored and to dismiss the batsmen during their bowling spell. Fielders were instructed to attempt a run-out at either end of the pitch each time the batsmen attempted to score. If no run was attempted, fielders were required to throw the ball to the wicketkeeper. If during a bout the batting pair was a combination of a right- and left-handed batsmen, fielders were required to move accordingly to maintain the same field setting. When a ball was hit or thrown over the surrounding net, participants were instructed towards spare cricket balls placed on the exterior of the net in line with the popping crease at both ends and sides of the playing field (see Figure 1).

Physiological Measures

Heart rate was recorded continuously across both Battlezone sessions using a Polar Team^2 System (Polar Electro Oy, Kemple, Finland). Prior to the Battlezone sessions, participants completed the Yo-Yo Intermittent Recovery Test Level 1

whilst wearing a heart rate monitor to determine their individual maximum heart rate (HR_{max}). Absolute and relative time spent in heart rate zones [Zone 1 (0-50%HR_{max}), Zone 2 (51-75%HR_{max}), Zone 3 (76-85%HR_{max}), Zone 4 (86-95%HR_{max}) and Zone 5 (>95%HR_{max})] were calculated for each participant during each Battlezone bout. At the end of each bout, capillary blood samples (5 μL) were drawn from a hyperaemic earlobe of all batsmen and bowlers and analysed for blood lactate concentration (Lactate Scout, EKF Diagnostics, Magdeburg, Germany). Following each bout, all batsmen and bowlers were required to provide a rating of perceived exertion (RPE) using the category-ratio 10 (CR-10) RPE scale.

Time-Motion Characteristics

The movement demands of Battlezone were quantified using 10 Hz MinimaxX global positioning system (GPS) devices (Catapult Innovations, Melbourne, Australia). All participants wore a harness that located the unit between the scapulae. Each GPS device was turned on in an open area 15 min prior to participants being fitted with the units to ensure a satellite lock was established. Data were downloaded and analysed following each Battlezone session using the Logan Plus 4.6 software (Catapult Innovations, Melbourne, Australia).

All movement data was calculated as time spent and distance covered in ascending movement zones [standing/walking (0-2.00 $m \cdot s^{-1}$), jogging (2.01-3.50 $m \cdot s^{-1}$), running (3.51-4.00 $m \cdot s^{-1}$), striding (4.01-5.00 $m \cdot s^{-1}$) and sprinting (>5.01 $m \cdot s^{-1}$)] (Petersen et al., 2010). Work-to-recovery ratio was defined as the ratio of time spent completing high- (running, striding, sprinting) to low-intensity (standing/walking, jogging) activities as per Petersen et al. (2010). The initial increase in velocity of the bowler who delivered the first ball of the bout, and when no increase in velocity after the final ball was delivered of the bout using

183 Logan 4.6 software (Catapult Innovations, Melbourne, Australia) signified the
184 start and end point, respectively of each 8 over bout.
185
186 *Statistical Analysis*
187 All data were reported as mean ± standard deviation (SD). Any data recorded
188 whilst a participant was not directly involved in a Battlezone bout was not
189 reported and not included in analyses. Independent samples t-tests ($p<0.05$)
190 were used to determine if movement demands and physiological responses
191 differed between each playing position between sessions. Within position
192 comparisons were calculated using paired samples t-tests ($p<0.05$). As outlined
193 in Hopkins (2000), the variability of each measure was calculated using the
194 typical error of measurement and expressed as co-efficient of variance (CV).
195 Intra-class correlation (ICC) was used to assess between-session reliability.
196 Statistical analyses were performed using the software package IBM SPSS
197 Statistics (version 19, IBM Corporation, Somers, New York, USA) and a
198 customised spreadsheet in Microsoft Excel 2003® developed by Hopkins (2009).
199

Results

Physiological Measures

Physiological responses recorded during generic Battlezone bouts are presented in Table 1. Across all playing positions, the $\%HR_{max}$ ranged from 78-89%; however, the majority of total time (74-92%) was spent within heart rate Zone 2 and 3 (51-85%HR_{max}) (Table 1). Fielders and wicketkeepers displayed increased percentage of time ($p<0.05$) within the heart rate zones 1, 2 and 3 to batsmen, medium-fast bowlers and spin bowlers. The highest $\%HR_{max}$ of fielders and wicketkeepers also significantly differed to batsmen and medium-fast bowlers, respectively. All other measures, including post-bout blood lactate concentration and RPE were not significantly different between each playing position ($p>0.05$).

*****INSERT TABLE 1 ABOUT HERE*****

Movement Demands

The total distances covered and mean speeds of each playing position during Battlezone training are presented in Table 2. Batsmen covered the greatest total distance (1147 ± 175 m) and high-intensity activity distance (225 ± 117 m) per 8 over bout. Medium-fast bowlers were not different to batsmen ($p>0.05$) in total distance covered. Wicketkeepers covered the least total distance (454 ± 258 m) compared to all other positions ($p<0.05$). Interestingly, wicketkeepers completed 428 ± 239 m of low-intensity activity, which was relatively similar to the other playing positions (batsmen: 80%; medium-fast bowlers: 90%; spin bowlers: 91%; fielders: 82% and wicketkeepers: 94%). Similarly, batsmen achieved the highest mean speed (63 ± 9 $m \cdot min^{-1}$) per Battlezone bout, followed by medium-fast bowlers (60 ± 10 $m \cdot min^{-1}$, $p>0.05$). In comparison fielders and wicketkeepers reported significantly ($p<0.05$) lower mean speeds per bout (Table 2) to batsmen

and medium-fast bowlers. Wicketkeepers also achieved a significantly lower ($p<0.05$) maximal speed (3.8 ± 1.5 $m \cdot s^{-1}$) in comparison to batsmen, medium-fast bowlers and fielders. Significantly different ($p<0.05$) distances at running, striding and sprinting speeds were too observed between batsmen, fielders and wicketkeepers, resulting in the greater distances within the high-intensity activity zone.

Further movement characteristics of all playing positions are presented in Table 3. The number of high-intensity efforts completed by batsmen significantly differed ($p<0.05$) to that completed by spin bowlers, fielders and wicketkeepers. The work-to-recovery ratio ranged from 23 ± 11 s for batsmen to 179 ± 88 s for wicketkeepers per Battlezone bout ($p<0.05$). This translated into significantly ($p<0.05$) shorter recovery times between high-intensity efforts for batsmen when compared to spin bowlers, fielders and wicketkeepers.

*****INSERT TABLE 2 AND 3 ABOUT HERE*****

Variability between Battle Zone Sessions

Within-position reliability between both generic Battlezone sessions for all movement demands and physiological responses are presented in Tables 1-3. Significant differences were observed within each respective position ($p<0.05$) for HR Zone 2 and 4, striding distance and the number of high-intensity efforts of medium-fast bowlers. All other measures displayed no difference ($p>0.05$) between BZ sessions within playing position. Measures of reproducibility from the physical and physiological data recorded during the generic Battlezone sessions are presented in Table 4. Both mean speed (CV: 7-9%) and total distance (5-17%) demonstrated acceptable variability across all playing positions in the current study. The most variable measure was the number of

high-intensity efforts completed during a bout, possessing a %CV of between 53-114% across a range of playing positions. The majority of measures possessed a moderate to high level of reliability (r=0.48-1.00). However, a greater number of measures demonstrated higher reliability in batsmen and fielders when compared to medium-fast bowlers and wicketkeepers (see Table 4). Mean speed ($m \cdot min^{-1}$) was the most reliable measure across all playing positions with ICC ranging between r=0.72-1.00. Total distance was also highly reliable across batsmen, fielders and wicketkeepers (r=0.89-0.97), although this was not the case for medium-fast bowlers (r=0.01).

Discussion

The primary aim of this study was to quantify the physiological and physical responses of a cricket-based small-sided game to be used in training environments. Secondly, this research aimed to report on the reproducibility of these measures between repeated Battlezone sessions. The main finding of the study was that across all playing positions the majority of time was spent between 51-85%HR_{max}, whilst blood lactate concentration and RPE for both batsmen and bowlers ranged from 1.1-2.0 mmol.L^{-1} and 4.2-6.0, respectively. Furthermore, the total distance travelled ranged from 450-1189 m, with mean speeds during Battlezone ranging between 24-66 m·min^{-1}. A secondary finding of the current study was that many of the physiological and movement demands during a generic Battlezone session exhibited satisfactory reliability, regardless of playing position; although measures of high-intensity activity in all positions showed high variability. Finally, based on the physiological responses elicited, Battlezone seems to be reliable and may provide a sufficient physical stimulus for a conditioning effect for cricket players.

Physiological Responses and Movement Demands

Batsmen

Across all the playing positions batsmen performed at higher intensities and elevated physiological responses during the generic Battlezone session. The majority of time (~79%) was spent within heart rate Zones 2 and 3, suggesting that a consistent and moderate physiological intensity was maintained. Similar to this, Nicholson, Cooke, O'Hara and Schonfeld (2009) reported that batsmen spent the majority of their time at a low to moderate intensity (≤85%HR_{max}: 84.1 ± 9.7%; >85%HR_{max}: 19.7 ± 6.9%), during an actual cricket match. Separately, while blood lactate concentration has been used to reflect the physiological demands of cricket, only Petersen, Pyne, Dawson, Kellett, & Portus (2011) have

reported on peak blood lactate concentration of players during cricket training. Despite no distinction between playing positions, the blood lactate concentration of players during match simulations in the study of Petersen et al. (2011), are similar to that of batsmen in this study. However, the low blood lactate values of the batsmen in the current study suggest that the physiological intensity of generic Battlezone sessions does not invoke high anaerobic metabolic demand. Taken together, this physiological data suggests that the intensity level of a generic Battlezone session is moderate, despite being interspersed with small periods of high intensity.

While limited data exists reporting on RPE of cricket batsmen, the current study reported data corresponding to a rating of 'somewhat-hard'. However, it remains unknown how this corresponds to time-scaled match-play data given the absence of RPE data recorded during cricket match play. Therefore, this may suggest Battlezone provides a similar perceived exertion for batsmen as a batting protocol designed to mimic match demands, albeit within a shorter training time.

Batsmen travelled considerably greater distance and demonstrated the highest mean speed during a generic Battlezone bout when compared to the other playing positions. This is most likely the result of batsmen completing the greatest number of high-intensity efforts in an attempt to secure the greatest amounts of runs in an innings. It is also possible that the Battlezone format itself allows batsmen to score more freely due to the fewer number of fielders and may be favourable towards a physical stimulus for batsmen. As a result of this, batsmen spent considerably less time walking (~50%) when compared to the bowlers and wicketkeeper. Despite the obvious difference in competitive standards, when compared to One-Day International batsmen (Petersen et al.,

2010), the current study suggests that a similar amount of time is spent performing high-intensity movements during a generic Battlezone bout. Furthermore, batsmen in Battlezone demonstrated a greater mean speed than that reported for a One-Day International. Taken together, it seems that generic Battlezone provides batsmen with a physically demanding training environment that is representative of match-play demands.

Medium-fast bowlers

In the current study, medium-fast bowlers spent the majority of time (~86%) in heart rate Zones 2 and 3, suggesting that the intensity was relatively moderate. Similarly, the heart rate responses demonstrated by the medium-fast bowlers in the current study are comparable to previous reports in which heart rate ranged from 75-85%HR_{max} during fast-bowling training protocols simulating match demands (Burnett, Elliott & Marshall, 1995; Duffield, Carney & Karppinen, 2009; Stretch & Lambert, 1999). Therefore, it seems plausible that Battlezone provides a stimulus similar to that of other training protocols and/or simulated match bowling. Furthermore, while limited research has reported on the blood lactate concentration responses during cricket match play, several studies have reported the responses during fast bowling protocols (Burnett et al., 1995; Duffield et al., 2009). The blood lactate concentration of medium-fast bowlers in the current study however, suggests that the contribution of anaerobic metabolism is limited during a Battlezone bowling spell. It is possible this lower blood lactate concentration value is due to the periods of low-intensity activity between overs. The RPE for medium-fast bowlers represented a rating of ‘hard’, which was less than that which has previously been reported in match simulations (Duffield et al., 2009). The greater RPE of participants in the study of Duffield et al. (2009) may be attributed to the greater number of overs performed by participants and the inclusion of scheduled low-intensity activity between

overs. Given that there is no available match-specific RPE data available for cricket match-play it is unknown if the lesser RPE recorded during Battlezone replicated the perceived intensity of a match.

Normally, fast bowlers cover the greatest distance during a typical cricket match (Petersen et al., 2010), although in the present study this was not the case. Distance covered is likely to be contingent on the number of overs completed; which may explain the contradictory results evident in the Battlezone session. Again, despite differences in competition standards, compared to the match data of Petersen et al. (2010), medium-fast bowlers covered a similar relative distance at both low- and high-intensities in each Battlezone bout in the current study, but a much lower absolute distance due to less overs bowled. This data suggests that while similar to the match demands of medium-fast bowlers, Battlezone may not provide a high level of physical intensity.

Spin Bowlers

The current data demonstrates that spin bowlers spent the majority (65%) of each Battlezone bout at a physiological intensity of between 51-85%HR_{max}. Spin bowlers also recorded the lowest blood lactate concentration measurements, despite reporting the highest perceived intensity. By comparison only limited data exists on the physiological demands of spin bowlers during a match, with the mean heart rate equal to approximately 135 $b \cdot min^{-1}$ during a Twenty20 match (Petersen et al., 2010).

The total distance travelled by spin bowlers was considerably less than that of the batsmen and medium-fast bowlers, which corresponded to a lower mean speed as well. Furthermore, the recovery time between each high-intensity effort was significantly longer than that of batsmen. In comparison to match demands

(Petersen et al., 2010) it seems spin bowlers in the current study do complete a similar ratio of low- and high-intensity activities, despite a relatively lesser overall distance being completed. When compared to other playing positions, the results of the current study also suggest that spin bowlers are less likely to perform extended periods of high-intensity activity. However, given that only one spin bowler was used per Battlezone session, a greater sample size is necessary to make such conclusions.

Fielders

Fielders demonstrated a lower heart rate response in comparison to other playing positions, with 74% of the time spent within heart rate Zone 2. Additionally, the amount of time spent above 85%HR_{max} was only 14% of the total time in each heart rate zone combined with the highest %HR_{max} per bout of 78% being achieved. Based on this evidence, it is evident that fielders maintain a low to moderate intensity during Battlezone. A similar trend was reported by Petersen et al. (2010) during Twenty20 matches whereby fielders mean and HR_{max} were considerably lower when compared to the other positions.

Furthermore, given the percentage of time performing low-intensity movements (~82%) being second lowest of all the playing positions, a low mean speed was evident with significantly less distance covered within each movement category compared to batsmen. Fielders also received a greater recovery time between work periods, most notably compared to that of batsmen, reiterating that fielding during a generic Battlezone scenario results in a moderate physiological stimulus suitable for training purposes. This is evident when compared to Petersen et al. (2010) in which fielders during One-Day cricket matches actually performed a higher percentage of low-intensity efforts and therefore, a slower mean speed. Further to this, these same fielders also received greater recovery

405 time between high-intensity efforts during a match in comparison to those during
406 Battlezone.
407
408 *Wicketkeepers*
409 The wicketkeepers spent a greater amount of time within heart rate Zone 2
410 compared to any other playing position. Similar to fielders, only ~10% of time
411 was spent at a high physiological intensity (>75%HR_{max}). Unsurprisingly,
412 wicketkeepers also recorded the lowest mean speed of all playing positions,
413 combined with the greatest total distance covered at a low-intensity. Given the
414 role of a wicketkeeper is to maintain a relatively sedentary position behind the
415 stumps, this skewed proportion within low heart rate zones and performing low-
416 intensity activities validly reflect the movement requirements of the position
417 (Petersen et al., 2010). Further evidence for the lower physiological demand of
418 wicketkeepers is the longest work-to-recovery ratio of all the playing positions.
419 However, it's possible that the results of the current study may have been
420 influenced by the Battlezone protocol itself. As wicketkeepers were not required
421 to change ends following each over, the amount of time remaining stationary
422 would have increased, hence may not reflect the match based demands of such
423 a position.
424
425 *Reproducibility of Small-Sided Cricket Games*
426 Previous research involving small-sided soccer games has established that
427 certain physiological and physical responses can be replicated both within and
428 between training sessions, most notably during smaller formats (Hill-Haas et al.,
429 2008; Rampinini et al., 2007). Accordingly, the secondary aim of the current
430 study was to determine the reliability of Battlezone sessions within respective
431 positions. Across each playing position (excluding spin bowlers due to a smaller
432 sample size) no significant differences existed in any of the physiological or

physical measures when comparing the two Battlezone sessions. Specifically, measures such as %HR_{max} achieved and total distance spent in specific movement categories were not significantly different between sessions. Remarkably, the mean speed and total distance covered by all participants was very similar between sessions, as reflected by the low CV and high ICC values (Table 4). However, both blood lactate concentration (mean CV: 46%) and RPE (23%) reported higher variability between sessions for batsmen and medium-fast bowlers. The number of high-intensity efforts completed per bout was the most variable measure reported regardless of playing position, which may be due to factors such as placement of the ball by both bowlers and batsmen during play. Unlike previous studies that have reported poor to moderate levels of reproducibility when using small-sided games as a training method (Hill-Haas et al., 2008; Rampinini et al., 2007), the data presented here suggest that during a skill-based sport such as cricket the variability between Battlezone sessions is reduced. This finding supports the observation of Petersen et al. (2010) where total distance covered during a cricket match was one of the least variable measures, and the number of sprints completed was one of the most variable. However, unlike Petersen et al. (2010) the movement demands were not always less variable than the physiological responses. Regardless, the use of Battlezone as part of cricket training or research design may be appropriate given the acceptable level of variability between respective sessions for physiological responses and movement demands.

Conclusion

The intended use of Battlezone is reported as a method to improve the technical and tactical abilities of cricket players within a match-intensive training environment. However, prior to this study it was unclear as to what external load and/or physiological responses were provided by Battlezone and whether such responses were reliable between sessions. The main finding of the current study was that the intensity and physical demands of generic Battlezone sessions were of moderate to higher intensities, particularly for batsmen and medium-fast bowlers, but to a lesser extent for spin bowlers, fielders and wicketkeepers. Such responses may also be comparable to previous match data and training protocols of elite cricket players, although further direct comparison of such data is required. It also appears that the generic version of Battlezone proved to be of acceptable reliability between sessions. Based on this evidence, cricket coaches can be confident that a consistent and effective training stimulus can be achieved when using a generic Battlezone scenario across all playing positions. As the technical nature of Battlezone remains unknown, coaches must be aware that traditional cricket-specific training should be implemented to compliment Battlezone.

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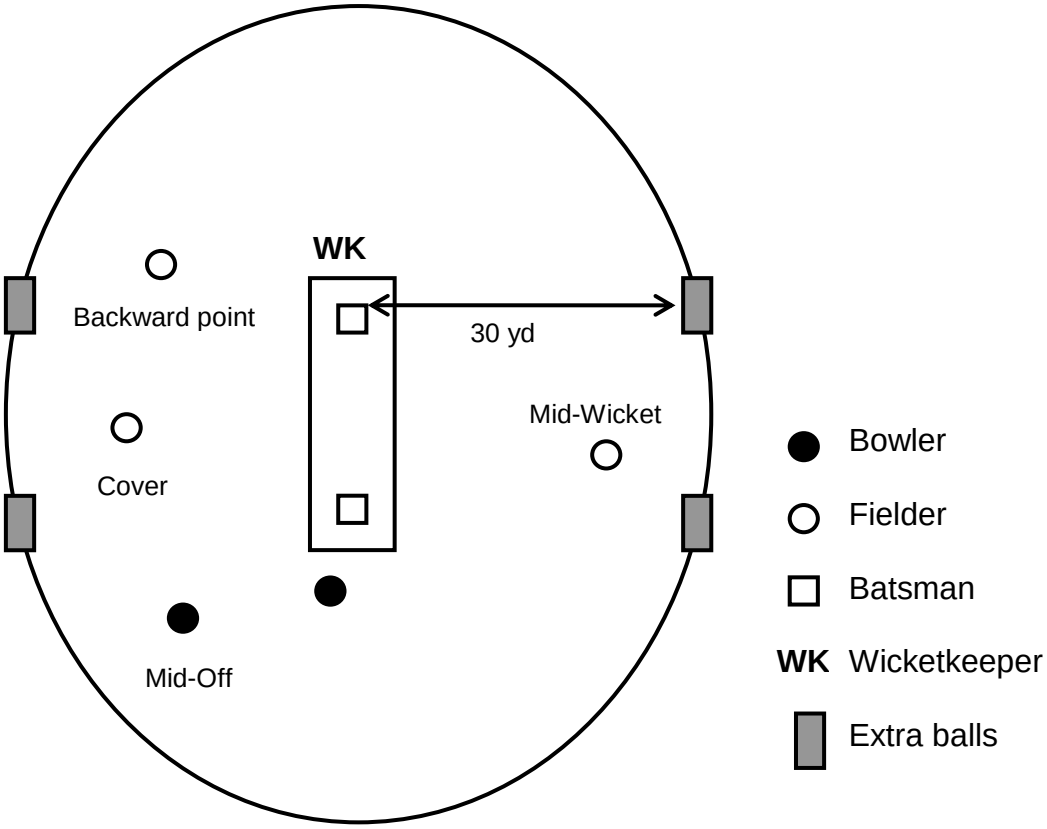

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544 **Figure 1:** Layout of Battlezone playing area for a right-handed batsmen

Table 1: Physiological and perceptual responses by position during a generic Battlezone bout (mean ± SD).

Position	Session	Peak %HR_{max}	Heart Rate Zones (% of time) 0-50%HR_{max}	51-75%HR_{max}	76-85%HR_{max}	86-95%HR_{max}	>95%HR_{max}	[BLa^-] ($mmol.L^{-1}$)	RPE (CR10)
Batsman (n=20)	1	91± 6	0	45 ± 40	29 ± 26	23 ± 29	1 ± 3	1.5 ± 0.5	4.2 ± 1.6
	2	87 ± 5	3 ± 8	50 ± 32	33 ± 23	14 ± 20	0	2.0 ± 0.9	4.6 ± 0.9
	Mean	89 ± 6	2 ± 4	48 ± 36	31 ± 25	19 ± 25	1 ± 2	1.8 ± 0.7	4.4 ± 1.3
Medium-fast bowler (n=8)	1	90 ± 10	0	46 ± 21	33 ± 11	19 ± 21	1 ± 2	2.0 ± 0.9	5.6 ± 1.0
	2	88 ± 0	2 ± 4	75 ± 18	21 ± 13	2 ± 3	0	1.6 ± 0.3	4.7 ± 1.3
	Mean	89 ± 5	1 ± 2	59 ± 20[#]	27 ± 12	11 ± 12[#]	1 ± 1	1.8 ± 0.6	5.2 ± 1.2
Spin bowler (n=2)	1	83 ± 10	7 ± 10	41 ± 58	1 ± 1	1 ± 1	0	1.1 ± 0.4	4.5 ± 0.7
	2	91 ± 1	0	45 ± 24	43 ± 23	5 ± 6	0	1.6 ± 0.4	6.0 ± 0.0
	Mean	87 ± 6	4 ± 5	43 ± 41	22 ± 12	3 ± 4	0	1.4 ± 0.4	5.3 ± 0.4
Fielder (n=18)	1	78 ± 8	7 ± 21	67 ± 32	14 ± 16	4 ± 8	0		
	2	78 ± 9	8 ± 12	80 ± 19	8 ± 11	2 ± 6	0		
	Mean	78 ± 9[a]	8 ± 17[b]	74 ± 26[c]	11 ± 14[a]	3 ± 7	0[b]		
Wicketkeeper (n=2)	1	80 ± 3	0	71 ± 39	12 ± 18	0 ± 1	0		
	2	76 ± 6	13 ± 17	80 ± 20	5 ± 11	2 ± 4	0		
	Mean	78 ± 5[b]	7 ± 9	76 ± 30[a,c]	9 ± 15[a]	1 ± 3	0		

[#] Significantly different ($p<0.05$) between sessions within playing position; [a] Significantly different to batsmen; [b] Significantly different to medium-fast bowlers; [c] Significantly different to spin bowlers

548 **Table 2:** Total distances (mean ± SD) covered in each movement category across playing positions during a generic Battlezone bout.
549

Position	Session	Distance Covered (m)								Mean speed ($m \cdot min^{-1}$)
		Walking (0-2.0 $m \cdot s^{-1}$)	Jogging (2.01-3.50 $m \cdot s^{-1}$)	Running (3.51-4.00 $m \cdot s^{-1}$)	Striding (4.01-5.00 $m \cdot s^{-1}$)	Sprinting (≥5.01 $m \cdot s^{-1}$)	Total Distance	Low-Intensity Distance (0-3.50 $m \cdot s^{-1}$)	High-Intensity Distance (≥3.51 $m \cdot s^{-1}$)	
Batsman	1	574 ± 80	350 ± 38	98 ± 33	102 ± 81	21 ± 33	1153 ± 185	924 ± 79	224 ± 140	59 ± 9
(n=20)	2	557 ± 29	352 ± 53	109 ± 29	95 ± 52	21 ± 20	1140 ± 165	909 ± 90	225 ± 93	66 ± 8
	Mean	566 ± 55	351 ±46	104 ± 31	99 ± 67	21 ± 27	1147 ± 175	917 ± 85	225 ± 117	63 ± 9
Medium-fast	1	793 ± 165	190 ± 55	71 ± 34	83 ± 47	27 ± 22	1189 ± 237	983 ± 213	199 ± 52	60 ± 10
bowler (n=8)	2	689 ± 143	221 ± 66	46 ± 38	33 ± 24	21 ± 40	1014 ± 263	910 ± 202	100 ± 70	59 ± 10
	Mean	741 ± 154	206 ± 61[a]	59 ± 36	58 ± 36[#]	24 ± 31	1102 ± 250	947 ± 208	150 ± 61[#]	60 ± 10
Spin bowler	1	587 ± 212	51 ± 17	14 ± 4	29 ± 11	16 ± 2	699 ± 218	638 ± 229	58 ± 13	38 ± 2
(n=2)	2	694 ± 76	136 ± 16	19 ± 15	41 ± 13	18 ± 25	907 ± 146	830 ± 93	77 ± 54	48 ± 1
	Mean	641 ± 144	94 ± 17[a]	17 ± 10[a]	35 ± 12[a]	17 ± 14	803 ± 182	734 ± 161	68 ± 34[a]	43 ± 2
Fielder	1	588 ± 274	195 ± 163	42 ± 33	58 ± 60	23 ± 36	909 ± 476	734 ± 403	123 ± 116	47 ± 23
(n=18)	2	550 ± 246	172 ± 114	43 ± 26	62 ± 47	28 ± 32	860 ± 395	722 ± 336	134 ± 100	49 ± 20
	Mean	431 ± 260[d]	184 ± 139[a,d]	43 ± 30[a,c,d]	60 ± 54[a,d]	26 ± 34[d]	885 ± 436[a,d]	728 ± 370[a]	129 ± 108[a,c]	48 ± 23[b,c]
Wicketkeeper	1	397 ± 238	42 ± 53	6 ± 7	10 ± 13	2 ± 3	458 ± 300	439 ± 285	18 ± 22	24 ± 17
(n=2)	2	378 ± 160	40 ± 33	9 ± 7	19 ± 16	3 ± 3	450 ± 216	417 ± 193	31 ± 25	26 ± 12
	Mean	388 ± 199[a,b,c]	41 ± 43[a,b]	8 ± 7[a]	15 ± 15[a]	3 ± 3[a,b,c]	454 ± 258[a,b]	428 ± 239[a,b,d]	25 ± 24[a,c,d]	25 ± 15[a,b]

550 [#] Significantly different ($p<0.05$) between sessions within playing position; [a] Significantly different to batsmen; [b] Significantly different to medium-
551 fast bowlers; [c] Significantly different to spin bowlers; [d] Significantly different to fielders

552 **Table 3:** Movement characteristics by position during a generic Battlezone bout (mean ± SD)

Position	Session	# of High-Intensity Efforts	# of Sprints	Maximal Speed ($m \cdot s^{-1}$)	Mean Sprint Distance (m)	Work-to-Recovery Ratio (1:x)
Batsman (n=20)	1	38 ± 24	3 ± 3	5.2 ± 0.5	5 ± 4	25 ± 11
	2	40 ± 16	3 ± 3	5.2 ± 0.6	5 ± 3	21 ± 10
	Mean	39 ± 20	3 ± 3	5.2 ± 0.5	5 ± 4	23 ± 11
Medium-fast bowler (n=8)	1	34 ± 10	3 ± 3	5.5 ± 0.3	11 ± 4	32 ± 25
	2	16 ± 12	2 ± 3	5.1 ± 0.8	4 ± 6	59 ± 33
	Mean	25 ± 11[#]	3 ± 3	5.3 ± 0.6	8 ± 5	46 ± 29
Spin bowler (n=2)	1	9 ± 2	1 ± 1	5.7 ± 0.1	15 ± 3	89 ± 43
	2	12 ± 6	2 ± 2	5.0 ± 0.5	6 ± 8	78 ± 40
	Mean	11 ± 4[a]	2 ± 2	5.3 ± 0.5	11 ± 6	84 ± 42[a]
Fielder (n=18)	1	17 ± 14	2 ± 3	5.1 ± 0.9	6 ± 6	51 ± 50
	2	21 ± 15	3 ± 3	5.4 ± 0.8	7 ± 6	57 ± 48
	Mean	19 ± 15[a]	3 ± 3	5.2 ± 0.9	7 ± 6	54 ± 49[a]
Wicketkeeper (n=2)	1	4 ± 4	1 ± 1	3.7 ± 1.5	2 ± 3	255 ± 142
	2	5 ± 4	1 ± 1	3.9 ± 1.7	3 ± 3	102 ± 33
	Mean	5 ± 4[a,b]	1 ± 1	3.8 ± 1.5[a,b,c]	3 ± 3[b]	179 ± 88[a]

553 [#] Significantly different ($p<0.05$) between sessions within playing position; [a] Significantly different to batsmen; [b] Significantly different to medium-
554 fast bowlers; [c] Significantly different to fielders

555 **Table 4:** Co-efficient of variance (CV) and intra-class correlation analysis (ICC)
556 by position between generic Battle Zone sessions for movement demands and
557 physiological responses

Position	CV	ICC
Batsmen		
Total Distance (m)	4.9	0.90
Mean speed ($m \cdot min^{-1}$)	9.4	0.56
Number HIA	56.7	-0.17
Work-to-Recovery Ratio (1:*x*)	66.3	0.12
[BLa^-] ($mmol.L^{-1}$)	23.5	0.37
RPE	19.9	0.68
Highest %HR_{max}	5.7	0.42
Medium-fast bowlers		
Total Distance (m)	11.4	0.01
Mean speed ($m \cdot min^{-1}$)	8.0	0.72
Number HIA	52.5	0.60
Work-to-Recovery Ratio (1:*x*)		0.00
[BLa^-] ($mmol.L^{-1}$)	25.8	0.48
RPE	24.4	-0.60
Highest %HR_{max}	5.9	0.00
Fielders		
Total Distance (m)	16.3	0.89
Mean speed ($m \cdot min^{-1}$)	6.7	0.96
Number HIA	114.3	0.70
Work-to-Recovery Ratio (1:*x*)		0.61
Highest %HR_{max}	8.1	0.73
Wicketkeepers		
Total Distance (m)	16.3	0.97
Mean speed ($m \cdot min^{-1}$)	6.7	1.00
Number HIA	98.1	0.31
Work-to-Recovery Ratio (1:*x*)		0.00
Highest %HR_{max}	8.1	-0.80

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