Abstract

This study investigated the physiological responses and movement demands associated with modified versions of small-sided games for cricket training, termed 'Battlezone'. Eleven (22.2 ± 3.6 y; 1.80 ± 0.06 m; 81.7 ± 11.4 kg) male, cricket players volunteered to perform each of four modified 8-over scenarios of Battlezone. Modifications to Battlezone included reducing the field size, removal of a fielder, a combination of these modifications and additional rule changes. Heart rate, blood lactate concentration, rating of perceived exertion and the movement patterns of participants were measured during each scenario. The total distances covered per 8-over bout ranged from 626 ± 335 m for wicketkeepers to 1795 ± 457 m for medium-fast bowlers; although similar distances ($p>0.05$) were covered within positions between the four different scenarios. Between scenarios, the greatest mean speed, heart rate and blood lactate responses occurred when the rules were changed, resulting in increased movement patterns ($p<0.05$), most notably for batsmen and wicketkeepers. In contrast, altering the playing field size or player number did not significantly influence ($p>0.05$) these responses. These results suggest that the physical demands of cricket-specific training can be increased via rule variations including hit-and-run activities, more so than field size or player number.

Introduction

Originally used to develop the skills and tactical abilities of athletes in match-simulated environments, small-sided games are often also employed by coaches as a way of improving physical capacities simultaneous to technical and tactical competencies (Hill-Haas, Dawson, Impellizzeri & Coutts, 2011). It has been reported that manipulations to the constraints of the small-sided games playing environment significantly influences activity demands and ensuing physiological responses (Foster, Twist, Lamb & Nicholas, 2010; Hill-Haas, Coutts, Dawson & Rowsell, 2010; Owen, Twist & Ford, 2004). In order to correctly prescribe training load, coaches attempting to manipulate the physical demands of a small-sided games training session require quantification of the physiological, physical and technical responses resulting from the manipulation of those constraints. In regards to the sport of cricket, whilst the physical and physiological demands are considerable and prolonged, historically a greater training emphasis is placed on development of technical abilities rather than physical capacities (Bartlett, 2003; Bartlett, Stockill, Elliott & Burnett, 1996; Burnett, Elliott & Marshall, 1995; Stretch, Bartlett & Davids, 2000). To accommodate both the physical and technical training demands within match-specific contexts, a small-sided games approach to cricket training (termed 'Battlezone') has been developed; placing players in simulated, match-intensive environments (Renshaw, Chappell, Fitzgerald, Davison & McFadyen, 2010). However, to date few studies quantify the physical demands or physiological responses to Battlezone or to how these responses are altered based on various types of Battlezone sessions.

Previous studies using small-sided games in soccer and rugby league training have shown that modifications to the number of players taking part can greatly influence the physiological responses (Gabbett, Jenkins & Abernethy, 2009; Hill-Haas et al., 2010; Hill-Haas, Dawson, Coutts & Rowsell, 2009a; Impellizzeri et al., 2006). Specifically, increases in heart rate, blood lactate concentration and rating of

perceived exertion (RPE) are typically observed when the number of players is reduced (Foster et al., 2010; Hill-Haas et al., 2009a). However, somewhat counter-intuitively, decreasing player numbers during small-sided games has contrastingly been reported to have little effect on the physical demands, as evidenced by the similar distances travelled in total and within specific speed zones by youth soccer players (Hill-Haas et al., 2009a; Jones & Drust, 2007). Conflicting data has also been reported for alterations to the size of the playing field (Foster et al., 2010; Rampinini et al., 2007). For example, Casamichana and Castellano (2010) reported increased heart rate and RPE during soccer small-sided games with larger fields; whereas Tessitore, Meesuen, Piacentini, Demarie and Capranica (2006) reported that the largest physiological responses were achieved on smaller sized fields.

Research in several football codes has also indicated physical and physiological demands can be manipulated via the use of altered playing rules, such as designating specific defensive and attacking zones or limiting the amount of possession by each player (Duarte et al., 2010; Gabbett et al., 2009; Hill-Haas et al., 2010; Hill-Haas, Rowsell, Dawson & Coutts, 2009b). Accordingly, it seems evident that the manipulation of the small-sided games constraints can affect ensuing physical demands and physiological responses; which may result in the manipulation of the imposed training load. However, research reporting on small-sided games has predominantly focused on football codes such as soccer and rugby league (Foster et al., 2010; Jones & Drust, 2007; Kelly & Drust, 2009; Owen et al., 2004). Given the particular importance of match-specific, small-sided games training for cricket, further understanding of the effects of modifications to small-sided games constraints and resulting physical and physiological demands are required.

A recent study has shown that a generic Battlezone training session provides cricket players with an adequate and consistent physical (mean speed: 25-66 $m \cdot min^{-1}$;

number of high-intensity activities: 5-40) and physiological training stimulus (%HR_{max}: 76-91%; RPE: 4.2-6.0) (Vickery, Dascombe, Duffield, Portus & Kellett, In Press). Furthermore, such a session represents a reliable and reproducible training stimulus (mean speed: co-efficient of variance= 6.7-9.4, intra-class correlation= 0.56-1.00) (Vickery et al., In Press). However, this study only reported the demands and between-session reliability of a generic 8-over scenario of Battlezone. To date no research reports the physiological and physical responses to modified versions of Battlezone. Therefore, the objective of this study was to examine the effect of rule modifications, player numbers and playing field size on the physical demands and physiological responses during Battlezone.

Methods

Participants

During each of the different Battlezone scenarios a total of 11 amateur, cricket players (age 22.2 ± 3.6 yr; stature 1.80 ± 0.62 m; mass 81.7 ± 11.4 kg) were recruited. Participants were first grade players in a district standard cricket competition and performed two cricket-specific training sessions per week. Each player provided verbal and written informed consent after the study was approved by the University of Newcastle Human Research Ethics Committee.

Procedures

Following familiarisation with all equipment and procedures, participants performed at least one version of a Battlezone session, for which the procedures and playing format have been described elsewhere (Vickery et al., In Press). Briefly, Battlezone consisted of six repeat 8-over bouts on a cricket pitch surrounded by a 0.8 m high cricket net on the 30 yd (27.4 m) inner circle of a standard cricket field. One bout of Battlezone required two bowlers to complete four alternating overs to a batting pair, with the remaining participants placed at specific positions on the Battlezone field. All participants performed as they would during a typical one-day cricket match, with normal cricket rules and regulations (International Cricket Council, 2009) being applied to each session. For the present study, these procedures were then adapted based on the required modifications (field size, player number, rule changes) for each of the four respective Battlezone scenarios. Each Battlezone session consisted of six bouts in total, of which, each bout included 8-overs lasting 21 ± 2 min.

Small-Sided Games Scenarios

Specific modifications were made to the generic Battlezone scenario based on common modifications used in other small-sided games studies, including player number, field size and rule alterations (Dellal et al., 2011; Hill-Haas et al., 2010; Kelly

& Drust, 2009). The specific variations to the generic Battlezone format in the current study included:

1. Field size: the 0.8 m high cricket net was located in a circle 30 m in radius, measured from the centre of the pitch as opposed to the 30 yd (27.4 m) oval used during One-Day matches (International Cricket Council, 2009). This resulted in an 18% reduction in playing area from the generic version of Battlezone.
2. Player number: the number of fielders on the field during each bout was reduced to 3 (excluding the wicketkeeper) from the normal 4 players, with the "cover" position removed.
3. Field size-player number: combination of both scenario 1 and 2.
4. Rule changes: The rules of the Battlezone session were modified as below:
    a. Batsmen must have attempted a run after each ball that was hit.
    b. Instead of bowlers completing 6 consecutive deliveries for an over, bowlers rotated after each delivery until both had completed 4 overs each.
    c. Fielders were required to throw each ball back to the wicketkeeper's end, as opposed to the bowlers end following each play.

Physiological Measures

The heart rate of each player was measured at 5 second intervals throughout each session (Polar Team^2 System, Polar Electro Oy, Kemple, Finland). Prior to Battlezone data collection, participants completed the Yo-Yo Intermittent Recovery Test Level 1 whilst wearing a heart rate monitor. Each individual's maximum heart rate (HR_{max}) was determined from the HR_{max} achieved prior to exhaustion during the Yo-Yo Intermittent Recovery Test Level 1. Measures of heart rate were expressed as a percentage of HR_{max} (Hill-Haas et al., 2009a) and classified into 5 intensity 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}) (Vickery et al., In Press). The absolute and percentage of time spent within respective zones for each player during each training session were also calculated (Hill-Haas et al., 2009a).

Capillary blood samples (5 μl) were obtained from a hyperaemic earlobe of each batsmen and bowler within three minutes of leaving the playing area after an 8-over bout. Samples were immediately analysed for blood lactate (Lactate Scout, EKF Diagnostics, Magdeburg, Germany). Both batsmen and bowlers also provided a rating of perceived exertion (RPE; CR-10 scale) after the 8-over bout. This protocol was completed throughout the entire training session for a total of six separate bouts of the same version of Battlezone.

Time-Motion Characteristics

Global positioning system (GPS) MinimaxX units (v6.65, Catapult Innovations, Melbourne, Australia) sampling at 10 Hz measured the distance and speed of player's movement patterns. Players wore a specially designed harness (GPSports, Canberra, Australia) placing the GPS unit between the shoulder blades. As instructed by the manufacturer, each GPS unit was turned on 15 min prior to players entering the playing area to ensure a satellite lock was established. Data was downloaded and analysed following each Battlezone session using customised software (Logan Plus 4.6 software, Catapult Innovations, Melbourne, Australia).

Speed zones used by previous research were selected for data analysis and consisted of: 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, Pyne, Dawson, Portus & Kellett, 2010). Work-to-recovery ratio was defined as the ratio of time spent completing high- (running, striding, sprinting) to low-intensity (standing/walking, jogging) activity (Petersen et al., 2010). The starting point of an 8-

171 over bout within each small-sided game coincided with the initial increase in velocity
172 using Logan Plus 4.6 software (Catapult Innovations, Melbourne, Australia).
173
174 *Statistical Analysis*
175 All data were reported as mean ± standard deviation (SD). Due to all players not
176 being involved in each 8-over bout any data recorded whilst a player was not
177 involved was disregarded. To determine the effect of playing environment, player
178 number and rule modifications, the physiological and physical measures were
179 compared with one-way repeated measures analysis of variance with Fisher's LSD
180 post hoc ($p<0.05$) test. Data was assessed for normality using a Kolmogrov-Smirnov
181 test. Statistical analyses were performed using the software package IBM SPSS
182 Statistics (version 19, IBM Corporation, Somers, New York, USA).
183

Results

The respective influence of reduced field size, reduced player number, reduced field size-player number and specific rule changes are described accordingly in the following sections specific to respective playing positions. The physiological responses of each playing position within each Battlezone scenario are presented in Table 1. Total distance within each movement category and mean speed within each scenario of each playing position are shown in Table 2. Finally, specific movement characteristics of each playing position during the respective Battlezone scenarios are presented in Table 3.

Batsmen

A higher peak $\%HR_{max}$ ($p<0.05$) was observed in the rule changes session compared to the other scenarios. However, no main effect was observed for mean heart rate (HR_{mean}) response between the different Battlezone scenarios ($p>0.05$). Similarly, no significant difference ($p>0.05$) in time spent within respective heart rate zones existed between the different scenarios. A main effect was present for RPE ($F(3,30)$: 8.431; $p\leq0.00$; $\eta^2=0.457$) for batsmen across the different Battlezone formats. Post hoc analysis revealed RPE to be significantly higher ($p<0.05$) during the rule changes format than all other variations, without differences between the other respective scenarios ($p>0.05$). Blood lactate concentration did not differ ($p>0.05$) between respective scenarios.

Total distance covered for batsmen did not differ ($p>0.05$) between respective Battlezone scenarios. However, a main effect between Battlezone formats for mean speed ($F(3,30)$: 4.415; $p<0.02$; $\eta^2=0.306$) and total sprinting distance ($F(3,30)$: 4,737; $p<0.01$; $\eta^2=0.321$) was evident. Specifically, the rule changes scenario resulted in the highest ($p<0.05$) mean speed and distance travelled whilst sprinting (Table 2). A main effect was also present between Battlezone scenarios for work-to-recovery ratio

(F(3,30): 3.726; p<0.05; η^2=0.293), with a significantly shorter (p<0.05) recovery time for batsmen evident during the rule changes scenario compared to the field size and player number scenarios. There were no other differences (p>0.05) in distance covered or speed zone movement characteristics for batsmen between other Battlezone scenarios.

Medium-Fast Bowlers

A main effect for HR_{mean} (F(3,21): 13.778; p ≤ 0.00; η^2=0.663) was observed between Battlezone scenarios. Specifically, a significantly greater (p>0.05) HR_{mean} was observed during the decreased player number format compared to all other scenarios. Further to this, the percentage of time spent within each heart rate zone was not different (p>0.05) between the Battlezone scenarios. A main effect (F(3,21): 3.659; p<0.03; η^2= 0.343) existed for blood lactate concentration between the Battlezone scenarios; with the field size-player number scenario resulting in a significantly (p<0.05) lower blood lactate compared to the respective field size and player number scenarios. The RPE of medium-fast bowlers following each bout was not different (p>0.05) between respective scenarios.

Measures of total distance and high-intensity movement characteristics were not different (p>0.05) between scenarios for medium-fast bowlers. A main effect (F(3,21): 3.988; p<0.03; η^2= 0.363) for total walking distance covered between Battlezone scenarios was evident, with a significantly lower distance (p<0.05) covered during the rule changes scenario compared to the player number or field size-player number.

Spin Bowlers

A main effect was evident for HR_{mean} (F(2,2): 1112.333; p≤0.01; η^2=1.000), highest $\%HR_{max}$ (F(2,2): 111.422; p ≤ 0.01; η^2= 0.991) and the percentage of time spent within heart rate Zone 2 (F(2,2): 20.355; p ≤ 0.05; η^2= 0.953) between the different

Battlezone scenarios for spin bowlers. Subsequent post hoc analyses revealed the heart rate response of spin bowlers was highest during the field size-player number scenario ($p<0.05$). Furthermore, significantly less time ($p<0.05$) was spent within heart rate Zone 2 during the field size-player number scenario than during the other scenarios. Both the blood lactate concentration and RPE of spin bowlers did not differ ($p>0.05$) between the respective scenarios. Furthermore, no main effects ($p<0.05$) for measures of total distance or any movement characteristics were observed between scenarios.

Fielders

No significant differences ($p<0.05$) were observed for heart rate, blood lactate concentration or RPE responses between any of the respective Battlezone scenarios during fielding activities. Furthermore, there were no main effects ($p>0.05$) for measures of total distance or any movement characteristics observed between different scenarios.

Wicketkeepers

A main effect was reported for HR_{mean} ($F(3,12)$: 8.200; $p \leq 0.01$; $\eta^2=0.653$), $\%HR_{max}$ ($F(3,12)$: 4.016; $p \leq 0.05$; $\eta^2=0.501$) and the percentage of time within heart rate Zone 2 ($F(3,12)$: 7.518; $p \leq 0.01$; $\eta^2=0.653$) and Zone 3 ($F(3,12)$: 3.656; $p \leq 0.05$; $\eta^2=0.487$). Post hoc analyses revealed a significantly lower HR_{mean} ($p<0.05$) in the field size-player number scenario compared to all others. Further, a significantly greater time ($p<0.05$) was spent in heart rate Zone 3 during the rule changes scenario in comparison to the field size-player number scenario.

Distance travelled at a striding pace showed a main effect ($F(3,12)$: 4.231; $p \leq 0.05$; $\eta^2=0.514$) across the Battlezone scenarios for wicketkeepers. Post hoc analysis revealed that wicketkeepers travelled the greatest distance at striding speeds in the

rule changes scenario compared to the player number and field size-player number scenarios. A main effect was also evident for the number of sprints performed per bout (F(3,13):3.500; p≤0.05; η^2=0.467) and for mean sprint distance (F(3,12): 8.649; p≤0.01; η^2=0.684) across scenarios. Post hoc analysis revealed that a greater number of high-intensity efforts and sprints, mean sprint distance and a shorter work-to-recovery ratio resulted from the rule changes scenario ($p<0.05$) when compared to other scenarios.

*****INSERT TABLE 1, 2 AND 3 ABOUT HERE*****

Discussion

The aim of this study was to examine the movement demands and physiological responses of cricket players during variations of small-sided games for cricket ('Battlezone'). The results demonstrated that the physiological and physical responses to different Battlezone match scenarios were affected by specific rule modifications, player numbers and the playing field size. Specifically, variations to the Battlezone playing rules i.e. 'hit and run' or alternating ball delivery, appeared to have a greater influence on increasing physiological and physical demands, particularly with respect to the demands of batsmen and wicketkeepers. These findings provide evidence on the manipulation of training loads through the use of small-sided games to implement match-specific training stimuli for cricket players.

Batsmen

The current data demonstrated that changing the playing rules of Battlezone had a greater influence on the physiological and physical demands of batsmen than the other Battlezone format changes. Despite a similar total distance covered by batsmen in each scenario per 8-over bout, the rule changes scenario resulted in a faster mean speed, which was reflected with an increased number of high-intensity efforts and a reduced work-to-recovery ratio. The increased movement demands of batsmen scenario is logically explained by the requirements of the hit-and-run rule change resulting in batsmen engaging in an increased volume of higher-velocity efforts coupled with less recovery. Consequently, these movement demands may explain the higher heart rate responses and RPE values also observed throughout the rule change scenario. In comparison, the use of the other Battlezone scenarios, including reduced player number or field size did not alter the physiological or perceptual load (as measured by heart rate, blood lactate concentration and RPE).

The results of the current study are similar to findings describing variations to small-sided games in other sports, whereby specific rule changes also significantly influenced physiological and physical demands (increased $\%HR_{max}$ and RPE, higher running intensity demands) (Hill-Haas et al., 2010; Hill-Haas et al., 2009b). Unlike previous small-sided games research (Hill-Haas et al., 2010; Owen et al., 2004; Rampinini et al., 2007), alterations to the field size or the number of players on the field had no significant effect on the demands of Battlezone training. One possible explanation for the lack of aforementioned differences between Battlezone scenarios may relate to the technical nature of the game of cricket, rather than dictated by player's aerobic fitness capacity. In the majority of Battlezone formats, batsmen were instructed to bat as they typically would during a One-day cricket match. However, during the rule changes scenario batsmen were placed into non-typical batting situations, such as running after hitting the ball when a run would not normally be taken or sprinting to one particular end of the pitch to ensure they were not out. Accordingly, the rule changes scenario significantly increased the running demands of batsmen, which thereby increased physiological and perceptual responses. Based on such findings, coaches wanting to increase the physical conditioning load of batsmen may wish to employ the rule changes scenario due to these increased running demands, although an important consideration is the ensuing effect on technical performance, which remains unknown.

Medium-Fast Bowlers

HR_{mean}, blood lactate concentration and the distance travelled at walking speed significantly differed between Battlezone scenarios, with no single Battlezone scenario providing medium-fast bowlers with a significantly greater exercise intensity or physical demand. The similarity in the required total of ball deliveries performed by medium fast-bowlers during Battlezone (e.g. similar number of bowling deliveries per bout over a similar distance) may have contributed to the lack of difference in movement demands between the scenarios. Unlike the batsmen who were forced to

alter movement patterns during rule changes, the bowlers resulted in similar movement demands and hence similar physiological responses across all variations of Battlezone used in the study. Furthermore, whilst an increased movement demand was noted in batsmen for the rule change scenario, the design of the rule changes scenario may have contributed to shorter distances covered for bowlers by combining the two-by-4 over bowling spells into a singular bout of 8-overs.

In comparison to a generic Battlezone setting, the physical demands of medium-fast bowlers were increased when variations were made to the playing rules or environment (Vickery et al., In Press). A considerably greater distance was covered at a greater speed when Battlezone was modified, combined with a greater number of high-intensity efforts and a reduced work-to-recovery ratio when changes were made to the constraints of a generic Battlezone scenario. However, changes made to the generic Battlezone sessions did not influence the physiological responses of medium-fast bowlers, despite changes in their movement characteristics (Vickery et al., In Press). Previous research (Vickery et al., In Press) has reported that a generic Battlezone scenario provides medium-fast bowlers with a similar physiological load as match-intensive environments . Therefore, the results of the current study suggest that the physiological stimulus of medium-fast bowlers were maintained across all Battlezone formats and as such any of the Battlezone scenarios used were suitable in providing an appropriate match-simulated load when compared to a relative time-matched duration of a match (Petersen et al., 2010).

Spin Bowlers

Comparisons between Battlezone scenarios resulted in varied physiological responses and movement demands of spin bowlers. Despite the field size-player number scenario appearing to increase the HR_{mean} and peak $\%HR_{max}$, this increase in physiological intensity was not reflected in blood lactate concentration or RPE. The

physical demands of spin bowlers varied between scenarios, with the slowest mean speed and longest work-to-recovery ratio being present in the reduced field size-player number. The low number of spin bowlers used in the current study presents a limitation in interpreting these physiological responses and movement characteristics, and hence future research should increase the number of spin bowlers used in Battlezone studies. As previously mentioned with medium-fast bowlers, regardless of the Battlezone format; the intensity and physical demands resulting from Battlezone may be adequate to provide spin bowlers with a simulated match-intensive stimulus.

Fielders

The respective changes to the Battlezone scenarios did not significantly change the physiological responses and movement demands of fielders in the current study. These results were surprising as the modifications to the small-sided games environment altered both batsmen and bowler responses, which in turn may be suggestive of an overall change in small-sided games intensity. It is possible that the different skill levels of the batsmen and bowlers (e.g. batsmen favouring leg-side or off-side shots, bowlers favouring a shorter or fuller length delivery), or that the changes to the Battlezone rules were biased more towards changes in demands of batsmen and bowlers, resulting in similarity between scenarios for physiological response and movement characteristics of fielders.

Despite no differences in measures of heart rate, blood lactate concentration and RPE for fielders, the results of the present study differ to that previously reported in Vickery et al. (In Press) for the demands of fielding during a generic Battlezone format. Modifications to the field size, player number and playing rules appeared to increase the physical demand of fielders, potentially providing a greater internal training load (heart rate and RPE), despite similar external loads (distance covered). In particular, fielders within the rule changes scenario produced a considerably

higher %HR_{max} combined with a greater total distance covered and a higher mean speed per bout (Vickery et al., In Press). Additionally, a greater number of high-intensity efforts and a shorter recovery time between these activities were reported during the rule changes scenario as opposed to a generic Battlezone scenario. Therefore, although the intensity and physical demand of fielders did not differ between Battlezone variations, changes to the playing environment or rules provide players within an increased intensity and physical demand compared to previous research (Vickery et al. in press).

Wicketkeepers

The modification of Battlezone scenarios appeared to result in increased physiological and physical demands of wicketkeepers. Similar to batsmen, the rule changes scenario had the greatest effect on the physiological responses and movement characteristics of wicketkeepers. Although similar heart rate responses were reported between the different scenarios of field sizes, player number and rule changes formats, it was during the latter that the greatest period of time was spent above 75%HR_{max}. The considerably shorter recovery time between high-intensity efforts in comparison to the other scenarios may also have contributed to the increased physiological responses of the rule changes scenario. Unfortunately, as the RPE of wicketkeepers were not recorded, it remains unknown if the perceived intensity of wicketkeepers changed with modifications to Battlezone. Regardless, the increased distance covered at striding pace by wicketkeepers can also be attributed to the rule changes made to the Battlezone session, likely requiring faster movement to the stumps due to the more regular running of the batsmen. Based on these findings, the physiological responses of wicketkeepers can be influenced by having the fielders only return the ball back to the wicketkeeper's end of the pitch during a Battlezone training session.

Conclusion

This study aimed to compare the physiological and movement demands of various forms of small-sided games for cricket training. The major findings suggest that the introduction of different playing rules i.e. hit-and-run, seemed to have the greatest influence on training intensity compared to the other Battlezone scenarios, specifically for batsmen and wicketkeepers. In contrast to previous research with other team sports (Hill-Haas et al., 2010; Hill-Haas et al., 2009a; Owen et al., 2004) changes to the playing field size had minimal effect on training intensity, particularly for medium-fast bowlers, spin bowlers and fielders. Regardless, the information from this study may be useful for coaches requiring manipulation of training loads through the use of small-sided games to implement match-specific training stimuli for cricket players. Given the high-intensity at which Battlezone was performed, particularly during the rule-changes scenario; combined with the ease at which different cricket match situations can be created within the Battlezone playing area, Battlezone may be more suitable when training for the shorter cricket formats (One-Day and Twenty20 matches). Future research should further aim to determine if the technical skills of players such as the accuracy of the bowlers or the quality of the shots played by batsmen are able to be influenced by changes to the playing environment and rules.

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Table 1: Physiological and perceptual responses by position during a bout of different Battlezone scenarios (mean ± SD)

Scenario and Playing Position	HR_{mean} ($b \cdot min^{-1}$)	Peak $\%HR_{max}$	Heart Rate Zones (% of time)					[BLa^-] ($mmol.L^{-1}$)	RPE (CR10)
			0-50%HR_{max}	51-75%HR_{max}	76-85%HR_{max}	86-95%HR_{max}	>95%HR_{max}		
Field Size									
Batsman (n=11)	153 ± 12	89 ± 7	0	31 ± 28	47 ± 23	22 ± 25	1 ± 1	3.1 ± 2.0	5.5 ± 1.0
Medium-Fast Bowler (n= 9)	145 ± 11	89 ± 6	0	39 ± 16	42 ± 13	20 ± 21	0	2.3 ± 1.0	4.7 ± 1.4
Fielder (n=16)	133 ± 13	84 ± 7	1 ± 1	78 ± 24	17 ± 16	3 ± 9	0		
Wicketkeeper (n=6)	144 ± 3	83 ± 2	0	51 ± 17	49 ± 16	0	0		
Player Number									
Batsman (n=12)	156 ± 14	90 ± 7	0	27 ± 35	33 ± 21	38 ± 31	1 ± 4	2.4 ± 1.6	5.2 ± 2.0
Medium-Fast Bowler (n=8)	174 ± 13[a]	89 ± 7	0	28 ± 29	34 ± 18	33 ± 29	4 ± 6	3.0 ± 1.6	5.7 ± 1.1
Spin Bowler (n=4)	132 ± 6	77 ± 6	0	91 ± 13	6 ± 8	6 ± 8	0	1.0 ± 0.0	3.0 ± 0.0
Fielder (n=12)	134 ± 19	84 ± 9	1 ± 3	71 ± 34	16 ± 19	11 ± 22	1 ± 2		
Wicketkeeper (n=6)	151 ± 11	87 ± 4	18 ± 40	27 ± 32	31 ± 33	4 ± 5	0		
Player Number and Field Size									
Batsman (n=12)	147 ± 13	86 ± 7	2 ± 5	47 ± 37	36 ± 23	15 ± 20	1 ± 2	1.9 ± 1.4	4.5 ± 1.6
Medium-Fast Bowler (n=10)	148 ± 9	87 ± 5	0	49 ± 27	35 ± 10	15 ± 26	0	1.5 ± 0.4[a,b]	5.1 ± 0.9
Spin Bowler (n=2)	162 ± 5[b]	92 ± 5[b]	0	9 ± 1[b]	61 ± 20	28 ± 22	0	1.5 ± 0.5	5.5 ± 0.7
Fielder (n=11)	129 ± 20	79 ± 9	7 ± 15	72 ± 34	12 ± 17	8 ± 19	0		
Wicketkeeper (n=6)	129 ± 4[a,b]	81 ± 4[b]	1 ± 3	92 ± 3[a,b]	5 ± 3[a]	0	0		
Rule changes									
Batsman (n=12)	158 ± 17	92 ± 7[a,c]	0 ± 1	26 ± 28	39 ± 20	27 ± 25	5 ± 14	3.0 ± 1.8	7.4 ± 1.6[a,b,c]
Medium-Fast Bowler (n=8)	147 ± 15	90 ± 8	0	47 ± 40	32 ± 29	17 ± 29	1 ± 2	1.6 ± 0.7	6.0 ± 2.2
Spin Bowler (n=4)	131 ± 5	84 ± 1	0	90 ± 4[c]	8 ± 4	0	0	1.9 ± 0.4	4.0 ± 1.4
Fielder (n=17)	141 ± 16	88 ± 8	0	58 ± 33	32 ± 24	9 ± 16	0		
Wicketkeeper (n=6)	145 ± 9[c]	85 ± 5	0	42 ± 32[c]	52 ± 27[c]	6 ± 7	0		

[a] Significantly different to field size scenario ; [b] Significantly different to player number scenario; [c] Significantly different to field size and player number scenario

Table 2: Movement category distances by position during a bout of different Battlezone training scenarios (mean ± SD)

Scenario and Playing Position	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	
Field Size							
Batsman (n=11)	548 ± 75	306 ± 75	112 ± 43	147 ± 67	63 ± 52	1228 ± 213	60 ± 9
Medium-Fast Bowler (n= 9)	981 ± 356	220 ± 67	85 ± 51	122 ± 115	4 ± 8	1422 ± 554	66 ± 22
Fielder (n=16)	806 ± 201	359 ± 304	102 ± 80	98 ± 50	14 ± 17	1395 ± 480	66 ± 22
Wicketkeeper (n=6)	468 ± 172	113 ± 115	16 ± 24	16 ± 24	6 ± 5	626 ± 335	29 ± 12
Player Number							
Batsman (n=12)	532 ± 63	339 ± 93	103 ± 31	109 ± 32	22 ± 14[a]	1114 ± 93	55 ± 8
Medium-Fast Bowler (n=8)	1085 ± 316	251 ± 83	82 ± 42	159 ± 126	17 ± 30	1623 ± 553	78 ± 19
Spin Bowler (n=4)	801 ± 91	350 ± 168	34 ± 34	77 ± 53	56 ± 52	1321 ± 36	67 ± 13
Fielder (n=12)	793 ± 175	375 ± 357	77 ± 84	91 ± 56	32 ± 45	1378 ± 576	67 ± 24
Wicketkeeper (n=6)	447 ± 131	86 ± 50	18 ± 20	13 ± 13	0	565 ± 196	28 ± 7
Player Number and Field Size							
Batsman (n=12)	548 ± 73	320 ± 57	125 ± 17[b]	156 ± 55[b]	40 ± 33	1207 ± 131[b]	55 ± 10
Medium-Fast Bowler (n=10)	1184 ± 238	305 ± 121	114 ± 35	160 ± 117	12 ± 16	1795 ± 457	77 ± 13
Spin Bowler (n=2)	690 ± 243	198 ± 160[b]	52 ± 54	48 ± 48	12 ± 17	1002 ± 40	45 ± 4
Fielder (n=11)	809 ± 283	278 ± 205	57 ± 25	85 ± 61	38 ± 45	1277 ± 513	58 ± 22
Wicketkeeper (n=6)	570 ± 228	139 ± 104	20 ± 11	8 ± 4	4 ± 7	742 ± 323	31 ± 11
Rule changes							
Batsman (n=12)	506 ± 48	326 ± 57	115 ± 42	147 ± 54[b]	74 ± 47[b]	1171 ± 142	67 ± 7[b,c]
Medium-Fast Bowler (n=8)	779 ± 149[b,c]	221 ± 48	72 ± 39	113 ± 84	14 ± 20	1249 ± 354[b,c]	71 ± 18
Spin Bowler (n=4)	719 ± 89[b]	255 ± 58	19 ± 15	21 ± 4	10 ± 6	1023 ± 159	57 ± 5
Fielder (n=17)	681 ± 137	480 ± 306	102 ± 76	94 ± 61	31 ± 26	1401 ± 432	80 ± 24
Wicketkeeper (n=6)	481 ± 114	103 ± 52	21 ± 13	39 ± 20[b,c]	17 ± 19	664 ± 182	37 ± 10[b]

[a] Significantly different to field size scenario ; [b] Significantly different to player number scenario; [c] Significantly different to field size and player number scenario

Table 3: Movement characteristics by position during a bout of different Battlezone training scenarios (mean ± SD)

Scenario and Playing Position	# of High-Intensity Efforts	# of Sprints	Mean Sprint Distance (m)	Work-to-Recovery Ratio (1:x)
Field Size				
Batsman (n=11)	57 ± 23	7 ± 5	9 ± 2	19 ± 8
Medium-Fast Bowler (n= 9)	49 ± 18	1 ± 2	3 ± 5	22 ± 12
Fielder (n=16)	32 ± 15	3 ± 2	6 ± 3	41 ± 32
Wicketkeeper (n=6)	10 ± 11	1 ± 1	8 ± 5	238 ± 143
Player Number				
Batsman (n=12)	46 ± 11[a]	4 ± 2[a]	9 ± 2	21 ± 8
Medium-Fast Bowler (n=8)	64 ± 16	4 ± 6	8 ± 6	16 ± 8
Spin Bowler (n=4)	22 ± 11	5 ± 3	10 ± 5	46 ± 35
Fielder (n=12)	30 ± 17	3 ± 3	8 ± 4	35 ± 16
Wicketkeeper (n=6)	7 ± 8	0[a]	0[a]	188 ± 97
Player Number and Field Size				
Batsman (n=12)	60 ± 17	6 ± 4	6 ± 3	17 ± 6
Medium-Fast Bowler (n=10)	52 ± 19	3 ± 4	5 ± 4	20 ± 8
Spin Bowler (n=2)	19 ± 18	2 ± 2	2 ± 1	111 ± 114
Fielder (n=11)	34 ± 17	4 ± 4	9 ± 3[a]	39 ± 22
Wicketkeeper (n=6)	8 ± 2	1 ± 1	5 ± 2[b]	189 ± 80
Rule changes				
Batsman (n=12)	61 ± 15[b]	8 ± 4[b]	9 ± 2	12 ± 3[a,b]
Medium-Fast Bowler (n=8)	50 ± 26	6 ± 9	6 ± 5	23 ± 20
Spin Bowler (n=4)	7 ± 2	1 ± 1	10 ± 7	58 ± 30
Fielder (n=17)	31 ± 14	3 ± 2	9 ± 5	23 ± 17
Wicketkeeper (n=6)	12 ± 6[b]	2 ± 1[b]	9 ± 2[b,c]	55 ± 12[a,b,c]

[a] Significantly different to field size scenario ; [b] Significantly different to player number scenario;
[c] Significantly different to field size and player number scenario