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Physical Characteristics, Movement Pattern, and Heart Rate Response of Indian Cricketers During Batting in Twenty20 (T20) Matches

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ABSTRACT

International Journal of Exercise Science 16(6): 1413-1425, 2023. The study aims to provide a morphological profile of Indian cricketers and find physiological demands and positional differences of the batsmen in T20 matches according to their batting order. Eighty-three male cricketers (age: 17.93 ± 2.23 years) participated in this study and categorized into upper-order (n = 36), middle-order (n = 35) and lower-order (n = 12) batsmen. Height, weight, body fat%, and somatotype were measured. Movement analysis and heart rate (HR) responses were recorded during batting in T20 matches using PolarV800 smart-watch and H7 HR sensor. Descriptive statistics, one-way ANOVA followed by post-hoc analysis examined group differences. Results indicated that upper-order batsmen were balanced mesomorph, middle-order batsmen were mesomorphic-endomorph, and lower-order batsmen were mesomorphic-ectomorph. Cricket-specific movement patterns showed that standing made-up the majority of time spent (54.1 - 60.9%), while maximum distance was covered by walking (68.5 - 73.3%) during batting. Lower-order batsmen spent significantly lesser time ($p < 0.01$; $d = 1.02$) in the crease and covered lesser total distance ($p < 0.05$; $d = 0.85$) compared to upper and middle-order batsmen, respectively. Upper-order batsmen maintained a significantly lower average HR throughout batting compared to middle ($p < 0.01$; $d = 1.07$) and lower-order ($p < 0.01$; $d = 2.04$) batsmen. Moreover, upper-order batsmen spent significantly more time in the low-intensity target HR (THR) zone (~9.9%) compared to the middle (~3.2%; $p < 0.01$; $d = 0.72$) and lower-order (~2.3%; $p < 0.05$; $d = 0.69$). Additionally, upper-order batsmen spent significantly less time (20.8%; $p < 0.01$) in the high-intensity THR compared to the middle (55.3%) and lower-order (52.2%) batsmen. Therefore, the findings highlight distinct movement and physiological demands associated with batting at different orders during T20 matches, which conditioning coaches and cricketers can utilize to optimize training programs and enhance individual performance.

KEY WORDS: Body fat%, somatotype, global positioning system, match demand, target heart rate

INTRODUCTION

More than a hundred countries throughout the world are recognized by the International Cricket Council (ICC), in which 82 countries feature in the ICC T20 team rankings (15). During the T20 World Cup in 2007, the Board of Control for Cricket in India (BCCI) announced to start off a franchise-based cricket league, the Indian Premier League (IPL). It ushers in revolutionary changes in the commercialization of cricket in India as well as globally. Now, IPL is the world's most influential cricket league, and players from all over the world take part in it. Traditionally, the game of cricket was played in specific seasons of the year. However, due to its increased popularity, it is now played throughout the year, with short-format 20-over matches (T20) being particularly common. T20 cricket is a batting-oriented game, and spectators particularly enjoy seeing the batting skills of the players. However, the other two specialized aspects, namely bowling and mandatory fielding, also hold great importance in determining the outcome of the match. T20 batting innings typically consist of four phases: the power play (1–6 overs), middle (7 - 11 overs), slog (12 - 16 overs), and death overs (17 – 20 overs) (Modekurti, 2020) and the team generally consist of 5 (±1) batting specialized cricketers, including wicketkeepers, 2 (1) all-rounders, and 4 (±1) bowling specialized cricketers (22). According to the 'Laws of Cricket' specified rules, which are maintained and owned by Marylebone Cricket Club (MCC), the basic intention of batsmen is to accumulate more runs, whereas bowlers and fielders will try to restrict the runs (19). Technological development and a unique pattern of game structure enhanced its commerciality (like power play, free hit, super over, etc.), which promotes professional approaches in training and developing cricket-specific skills using scientific concepts.

Cricket is a skill-oriented game, but performance largely depends on the physical and physiological status of the cricketers (8, 21). Sports like football (10), hockey (33), rugby (16), and beach soccer (6) are just a few of the sports whose physical demands have been studied in relation to the type, frequency, and duration of player activities. This knowledge is then applied to increase the specificity of training in order to achieve improved physiological adaptations and match performance. Currently, little is known about the physiological demands of cricket, as well as the time-motion profiles of a cricket match. A frequent antecedent for developing a conditioning program is to do a time-motion analysis of the movement patterns found in a sport. This approach is relatively new in cricket. A video-analysis based research on the movement patterns of batsmen who scored centuries in test cricket (n = 13) and one-day international (n = 5) found that the batsmen spent roughly 99% and 98% of the time in stationary, walking, and jogging movement patterns during test and One Day International matches, respectively (11). However, due to the increased precision, reliability, and practical convenience of Global Positioning System (GPS) technology, notational analysis and manually operated computer tracking software in sports are being superseded (4, 24). Wearable GPS trackers have recently been utilized to quantify the cricketers' positioning needs during different match formats (T20, one day, and test) (11, 25).

In this twenty-first century, the technological revolution has also compelled researchers to investigate the real field heart rate (HR) response of the cricketers along with movement patterns (31, 35). There are few published studies on the physiological demands of cricket (1, 21, 34), majority of those have focused on the physiological demands of bowling. Literature suggests, the explosive format of cricket like T20 matches demands higher levels of strength, power, agility, speed, reaction time, and mental ability than other formats (27, 29). However, limited research has been conducted on the physical and physiological demands of short-format cricket and remains inconclusive. Only a few researchers have tried to explore the physiological characteristics of cricketers during batting using a simulated battle zone (9, 35, 36). Some researchers explored the physiological demands of the batsman during comparative short format matches (9, 31, 36). However, the scientific knowledge about real-field match demands is still missing. Therefore, this study was carried out to understand the movement pattern and physiological demand of sub-elite cricketers while batting in T20 matches according to their batting order. The secondary objective is to find the morphological characteristics of different order batsmen as well. The findings of the study will help cricketers, physical trainers, coaches, and sports science experts to understand the batting demand in T20 matches, and to design effective training plans using an optimum prescription of load, volume, and intensity.

METHODS

Participants

Eighty-three state level male cricketers registered with The Cricket Association of Bengal (CAB), Eden Gardens affiliated with the Board of Control for Cricket in India (BCCI), having more than 5 years of playing experience have been selected for this cross-sectional study. The cricketers with injury, history of cardiovascular surgery, and under any medication were excluded from this study. Out of the 83 participants, 36 were classified as being predominantly upper order batsmen, 35 were middle order batsmen, predominantly all-rounders, and 12 were lower order batsmen or predominantly bowlers. Demographic details of the cricketers are shown in Table 1. The study was conducted according to the Declaration of Helsinki and the ethical guidelines described by Navalta et al. (2019) (20). Institutional Ethical Committee has approved this study and written informed consent was obtained from the participants who were 18 years and above age or from their parents or guardians who were below 18 years of age before participating in this research.

Protocol

Compared to one-day or test matches, a fluid or dynamic batting order is very common and growing in professional T20 matches. In T20s, batting order changes based on the match demand, insights gleaned from statistics, observations of how the match is evolving, or simple gut feeling irrespective of the cricketers' specialization (39). Therefore, in this observational study, the cricketers were divided into three categories based on their appearance in the batting order of the match - 1) upper order batsman (1st to 4th position), 2) middle order batsman (5th to 7th position), and 3) lower order batsman (8th to 11th position). At the beginning, the participants went through a health checkup, and anthropometric measurements were taken. Movement analysis and HR response were recorded during batting in inter-districts and first division T20 matches from 2018 to 2021 cricket sessions. The average area of the cricket grounds was 8500m2. Match days' ambient temperature (range: 32°C - 39°C), humidity (range: 63 - 88%), and wind speed (range: 0 - 9.0 km/h) were noted from the local weather reports. Those participants who spent more than five minutes in the crease while batting during a match were included in the analysis. The venue, match timing, pitch condition, opponent team, toss result, bowling change, field positioning, batting order, and match scores were not controlled by the researchers during the study.

Anthropometric parameters such as height and body mass were measured using an anthropometric rod (GPM model 101 Swiss anthropometer) and weighing machine (Omran, model no: HN 289), respectively. Biceps, triceps, subscapular, and supraspinal skinfold thicknesses were measured using the Harpenden skinfold caliper (Baty International, model SCH 80, UK), and humerus and femur breadth were measured using spreading calipers (Galaxy, India), flexed arm and calf girths were measured using anthropometric tape (Cescorf, Brazil). All the measurements were taken from the left side of the body by a certified anthropometrist. Body fat% was estimated from the 4 skinfold measurements using Siri's equation (32). The somatotypes of the participants were calculated using the Heath-Carter manual (5).

Time-specific movement activities of the cricketers were measured by the Global Positioning System (GPS) enabled Polar V800 smartwatch, Finland. The watches were fitted in the participating player's wrist with the dial facing outward during batting. An approximate two minutes' stabilization period was given before starting the watch. High GPS accuracy mode was selected to obtain better positional accuracy of the watch. The participants were familiarized with the device prior to the test. The data was downloaded and processed at the end of each session using Polar Flow sync software (Polar Electro, Finland). Movements and distance traveled by the players during batting were divided into five categories: a) standing or minimal movement (< 0.5 m/s); b) walking (0.5 - 2.0 m/s); c) jogging (2.0 - 3.5 m/s); d) running or striding (> 3.5 m/s) and the cumulative distance and time covered in each of these movement categories were determined both in absolute and relative terms in line with those mentioned by other researchers (24, 31).

Resting HR on the match day and beat-to-beat HR during batting was measured using Polar H7 HR sensor, Finland. The HR sensor was positioned at the center of the chest and just below the sternum using a chest strap and was synchronized with the Polar V800 smartwatch. The HR of each participant was monitored continuously while batting. Peak HR and average HR during batting were calculated. Maximum HR was estimated using the Haskell & Fox equation: 220 - age (years) (12). The Karvonen formula (Target HR (THR) = $[(HR_{max} - HR_{rest}) \times \%intensity] + HR_{rest}$) was used to predict the target HR training zones (30).

Table 1. Demographics of the cricketers.

Variables	Upper order (*n* = 36)		Middle order (*n* = 35)		Lower order (*n* = 12)	
	Mean ± SEM	95% CI	Mean ± SEM	95% CI	Mean ± SEM	95% CI
Age (years)	17.6 ± 0.4	16.9 - 18.4	18.4 ± 0.4	17.6 - 19.2	17.4 ± 0.3	16.7 - 18.2
Height (cm)	168.4 ± 0.8	166.8 - 170.1	169.8 ± 1.0	167.8 - 171.8	170.6 ± 1.1	168.1 - 173.1
Body mass (kg)	60.1 ± 1.5	57.1 - 63.0	62.0 ± 1.7	58.5 - 65.5	60.8 ± 3.6	52.9 - 68.8
BMI (kg/m²)	21.1 ± 0.4	20.3 - 21.9	21.4 ± 0.5	20.4 - 22.4	20.8 ± 1.0	18.6 - 23.0

n = number of subjects; SEM = standard error of mean; CI = confidence interval; BMI = Body mass index

Statistical Analysis
Normality and homogeneity of the data were analyzed using the Anderson-Darling test and Levene's test, respectively. Descriptive statistics were done and the data were presented as mean ± standard error of mean (SEM) and 95% confidence interval (CI). One-way ANOVA followed by Tukey's post-hoc analysis was performed to find the differences between the groups. The time series analysis model (moving average) of HR response during batting was also done. All statistical analysis was done using IBM Statistical Package for Social Sciences (SPSS) (ver. 20) and Gnumeric spreadsheet software (ver. 1.10.16). The $p < 0.05$ was considered to be statistically significant. In addition to acquiring *p*-value, Cohen's *d* effect size (small = 0.2, medium = 0.5, large = 0.8) was also calculated to measure the magnitude of difference (13).

RESULTS

Body composition measures of the T20 cricketers are presented in Table 2. No significant ($p > 0.05$) differences were observed in the body fat% and somatotype rating of the cricketers among the groups. However, it was found that upper-order batsmen were balanced mesomorph, middle-order batsmen were mesomorphic-endomorph, and lower-order batsmen were found to be mesomorphic-ectomorph.

Table 2. Somatotype and body fat% of the cricketers.

Variables	Upper order (n = 36)		Middle order (n = 35)		Lower order (n = 12)		p-value
	Mean ± SEM	95% CI	Mean ± SEM	95% CI	Mean ± SEM	95% CI	
Endomorphy	3.2 ± 0.2	2.8 - 3.6	3.3 ± 0.3	2.8 - 3.9	3.0 ± 0.4	2.1 - 3.9	0.747
Mesomorphy	3.4 ± 0.2	3.1 - 3.8	3.6 ± 0.2	3.3 - 3.9	3.6 ± 0.3	3.0 - 4.1	0.824
Ectomorphy	3.1 ± 0.2	2.7 - 3.4	3.0 ± 0.2	2.6 - 3.5	3.4 ± 0.5	2.4 - 4.4	0.631
Body fat%	14.7 ± 0.7	13.4 - 16.1	14.9 ± 1.0	12.9 - 16.8	14.0 ± 1.5	10.7 - 17.3	0.868

n = number of subjects; SEM = standard error of mean; CI = confidence interval.

Movement patterns of the batsmen during T20 matches were analyzed and presented in Table 3. It was observed that lower order batsmen spent significantly lesser time ($p < 0.01$; $d = 1.02$) in the crease and covered significantly lesser total distance ($p < 0.05$; $d = 0.85$) compared to upper and middle order batsmen, respectively. Absolute movement characteristics showed that lower-order batsmen also covered significantly less time in standing ($p < 0.01$; $d = 1.22$) and walking ($p < 0.05$; $d = 1.0$) while batting in T20 matches compared to upper-order batsmen. Whereas, no significant differences ($p > 0.05$) were found in relative movement characteristics (%) across the different batting positions (Figure 1). Surprisingly, standing made up the maximum amount of time (around 54.1 to 60.9%) for all the batsmen during T20 matches, whereas the maximum distance was covered by walking (around 68.5 to 73.3%) during batting. In running or sprinting, minimal time was spent (around 0.1%) and minimal distance was covered (around 1%) during the T20 matches across the groups.

Table 3. Time-motion analysis of T20 cricketers during batting.

Variables		Upper order (n = 36)		Middle order (n = 35)		Lower order (n = 12)		p-value
		Mean ± SEM	95%CI	Mean ± SEM	95%CI	Mean ± SEM	95%CI	
Distance covered (m)	Standing (<0.5m/s)	102.2 ± 12.1	77.6 - 126.9	83.2 ± 10.5	61.8 - 104.5	41.8 ± 10.4 ^{a*}	18.9 - 64.7	0.023
	Walking(0.5-2.0m/s)	585.3 ± 59.7	464.1 - 706.5	598.8 ± 76.9	442.5 - 755.2	298.4 ± 59.3	167.9 - 428.9	0.062
	Jogging (2.0-3.5m/s)	131.3 ± 12.9	105.1 - 157.5	160.8 ± 18.4	123.4 - 198.3	90.1 ± 27.5	29.5 - 150.6	0.074
	Running(>3.5m/s)	10.4 ± 1.6	7.0 - 13.7	14.5 ± 3.4	7.7 - 21.3	9.7 ± 4.0	1.0 - 18.4	0.461
	Total distance (m)	818.3 ± 74.3	667.5 - 969.0	857.3 ± 103.8	646.3 - 1068.3	440.0 ± 95.2 ^{b*}	230.6 - 649.5	0.057
	Max. speed (m/s)	3.7 ± 0.1	3.2 - 4.0	3.7 ± 0.1	3.6 - 3.9	3.6 ± 0.2	3.2 - 4.0	0.710
Time spent (sec)	Standing (<0.5m/s)	1131.1 ± 136.5	854.0 - 1408.2	799.2 ± 82.3	631.8 - 966.6	405.8 ± 55.3 $^{a\#}$	282.5 - 529.1	0.003
	Walking(0.5-2.0m/s)	648.9 ± 68.2	510.5 - 787.4	531.7 ± 58.6	412.2 - 651.2	314.8 ± 67.1 ^{a*}	167.1 - 462.4	0.025
	Jogging (2.0-3.5m/s)	61.4 ± 7.3	46.6 - 76.2	60.8 ± 7.1	46.2 - 75.3	34.7 ± 10.6	11.3 - 58.0	0.141
	Running(>3.5m/s)	2.7 ± 0.4	1.8 - 3.5	2.6 ± 0.5	1.5 - 3.6	2.5 ± 1.0	0.2 - 4.8	0.971
	Total time (sec)	1844.1 ± 205.1	1427.6 - 2260.5	1464.0 ± 155.2	1148.2 - 1779.8	849.6 ± 173.5 $^{a\#}$	467.8 - 1231.4	0.022

n = number of subjects; SEM = standard error of mean; CI = confidence interval; ns = not significant; * = p<0.05; # = p<0.01; a = compared to upper order; b = compared to middle order.

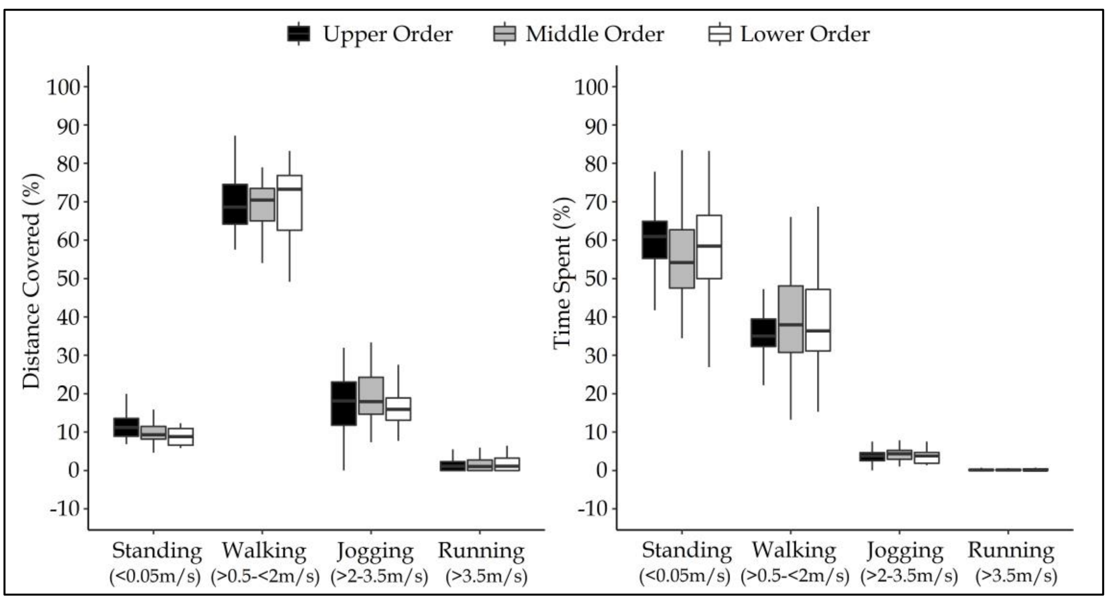

Figure 1. Box plot represents the percentage of distance covered and time spent during batting in T20 matches by different order batsmen.

HR responses of the cricketers while batting during T20 matches are presented in Table 4. There was a significant difference observed in average HR and peak HR between the groups.

Throughout batting, the average HR of upper-order batsmen was significantly lower compared to middle ($p < 0.01$; $d = 1.07$) and lower-order ($p < 0.01$; $d = 2.04$) batsmen. Upper-order batsmen also reached a significantly lower ($p < 0.001$; $d = 0.90$) peak HR than the middle-order group, whereas no significant differences were observed in resting HR, minimum HR, and HR reserve among the groups. HR responses during batting in T20 matches according to batting order have been displayed in figure 2. Beat-to-beat HR dynamics of upper-order batsmen during batting in T20 matches were relatively lower (average: 141.5 ± 2.4) compared to the middle (average: 157.4 ± 2.6) and lower-order (average: 163.3 ± 4.6) batsmen. However, an increment in HR kinetics has been observed for each group. Surprisingly, a significant difference has also been observed in initial HR responses during batting (Table 4). Initial HR responses of upper order batsmen were significantly lower than middle order ($p < 0.05$; $d = 0.68$) and lower order ($p < 0.01$; $d = 0.75$) batsmen, however, no significant differences were observed in resting HR.

Table 4. Heart rate response at the beginning and during batting in T20 matches.

Variables	Upper order (*n* = 36)		Middle order (*n* = 35)		Lower order (*n* = 12)		*p*-value
	Mean ± SEM	95%CI	Mean ± SEM	95%CI	Mean ± SEM	95%CI	
HR_{rest} (bpm)	59.9 ± 0.8	58.2 - 61.6	58.2 ± 0.8	56.6 - 59.8	61.4 ± 1.5	58.1 - 64.7	0.113
$HR_{initial}$ (bpm)	132.1 ± 2.7	126.7 - 137.5	143.7 ± 3.0 ^{a*}	137.6 - 149.8	147.3 ± 6.8 $^{a\#}$	132.8 - 162.7	0.007
HR_{avg} (bpm)	141.5 ± 2.4	136.7 - 146.3	157.4 ± 2.6 $^{a\$}$	152.1 - 162.7	163.3 ± 4.6 $^{a\$}$	153.3 - 173.4	<0.001
HR_{peak} (bpm)	178.1 ± 2.6	172.8 - 183.5	191.8 ± 2.5 $^{a\$}$	186.7 - 196.9	189.3 ± 3.5	181.7 - 197.0	<0.001
HR_{min} (bpm)	100.1 ± 4.1	91.7 - 108.5	108.4 ± 5.5	97.2 - 119.6	127.2 ± 7.1 ^{a*}	111.5 - 142.9	0.054

n = number of subjects; SEM = standard error of mean; CI = confidence interval; * = p < 0.05; # < 0.01; $ = p < 0.001; a = compared to upper order; b = compared to middle order.

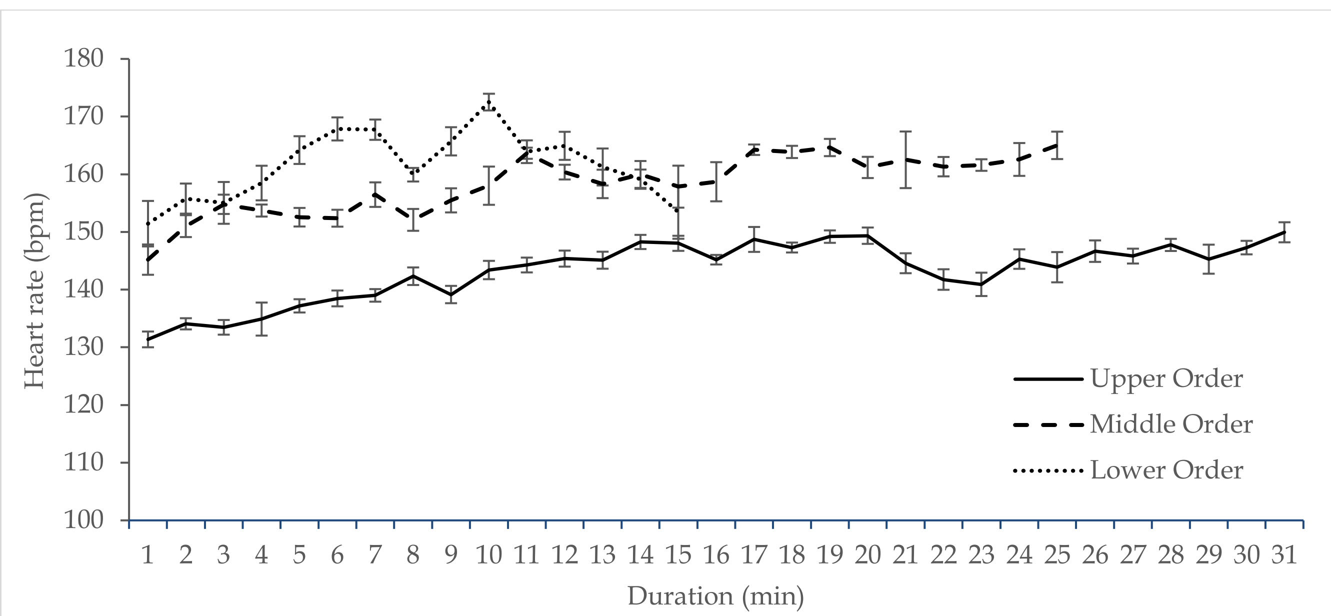

Figure 2. Heart rate dynamics during batting by various batting order batsmen throughout the duration of their play.

A substantial variation in the time spent in various THR zones during batting has been observed in the study (Table 5). Interestingly, upper-order batsmen spent significantly greater time in the low-intensity THR zone (~9.9% of total time) compared to the middle order (~3.2%) ($p < 0.01$; $d = 0.72$) and lower order (~2.3%) ($p < 0.05$; $d = 0.69$) batsmen. It was also observed that lower order batsmen (52.2%) and middle order batsmen (55.3%) played most of the time in the high-intensity THR zone during batting, whereas upper order batsmen (68.6%) played most of their time in the moderate-intensity THR zone. Upper order batsmen spent significantly ($p < 0.01$) less time (20.8%) during their batting duration in the high-intensity zone compared to the middle order (55.3%) and lower order (52.2%) batsmen.

Table 5. Percentage of time spent in specified target heart rate (THR) zone during batting in T20 matches.

Variables		Upper order (*n* = 36)		Middle order (*n* = 35)		Lower order (*n* = 12)		*p*-value
		Mean ± SEM	95%CI	Mean ± SEM	95%CI	Mean ± SEM	95%CI	
Low intensity	<30% THR	2.2 ± 1.6	0.4 - 6.9	1.4 ± 1.2	0.0 - 4.6	0.2 ± 0.2	0 - 0.6	0.393
	30-40% THR	7.7 ± 1.8	4.3 - 11.7	1.8 ± 0.7 [a#]	0.8 - 3.8	2.1 ± 1.2 [a*]	0 - 4.8	0.014
Moderate intensity	40-50% THR	18.4 ± 2.1	14.1 - 22.7	7.1 ± 1.5 [a$]	4.8 - 11.1	13.8 ± 3.7 [a*]	0.9 - 17.1	<0.001
	50-60% THR	25.7 ± 2.1	21.4 - 29.8	14.9 ± 2.2 [a#]	11.2 - 20.3	12.3 ± 3.4 [a$]	2.7 - 17.9	<0.001
	60-70% THR	24.5 ± 2.4	19.7 - 29.3	19.6 ± 2.1	16.4 - 24.8	19.4 ± 3.3	10.7 - 25.1	0.235
High intensity	70-80% THR	16.3 ± 2.2	9.8 - 18.8	22.3 ± 2.1 [a*]	19.0 - 27.5	24.4 ± 4.7 [a*]	15.8 - 36.4	0.005
	80-90% THR	4.5 ± 1.3	2.0 - 1.8	20.3 ± 2.7 [a$]	12.7 - 23.4	18.9 ± 5.5 [a$]	11.0 - 35.3	<0.001
	>90% THR	0.7 ± 0.5	0.0 - 1.8	12.7 ± 2.3	5.3 - 14.7	8.9 ± 4.3	1.6 - 20.7	0.393

n = number of subjects; SEM = standard error of mean; CI = confidence interval; THR = Target heart rate, Significance level: * < 0.05; # < 0.01; $ = p < 0.001 and a = compared to upper order, b = compared to middle order.

DISCUSSION

Anthropometric characteristics and movement patterns of the batsmen, bowlers, and fielders during one-day and test matches have been investigated by various researchers. However, to our knowledge, this is the first study that monitored Indian batsmens' movement patterns and HR responses according to batting order during T20 matches along with anthropometric variations. In this uncertain team sport, a team starts batting in the 1st innings without any specific run chase whereas another team starts the 2nd innings with a specific target, which affects the team strategy and batting order of the batsmen. Thus, winning T20 matches are associated with several independent and dependent factors such as pitch condition, match pressure, bowling strategy, field placement, toss, etc. (22, 23), effective batting tactics and strategies, as well as having an optimum physical and physiological status of the batsmen is also responsible for success in batting.

Physical characteristics of different order batsmen: The present study reveals that the anthropometric characteristics of the upper, middle, and lower order batsmen were relatively similar. No significant differences were observed in body mass, height, BMI, and body fat% of the cricketers among the groups. Although it was noticed that the average height of the cricketers was higher than the overall population of the state (18) as well as the Indian population aged between 15 to 25 years (7). It is well established that height mostly depends on the genetic potential of an individual, nutritional intake value in early childhood, and socioeconomic status as well (18). In this study, no significant differences were observed in BMI which is consistent with the previous findings on inter-university male cricketers in India, who had a mean BMI of 21.1 kg/m^2 (17), and regional U-19 batters in West Bengal, who had a mean BMI of 21.3 kg/m2 (2). BMI along with body fat% provides a comprehensive picture of the physical make-up of any individual. Previous studies reported that the body fat% adversely affects the cardiovascular endurance, speed, and agility of cricketers (3). However, in this study, the body fat% of the batsmen was within the normal range as reported in other studies (2, 17) and no significant differences were observed between the groups.

In somatotype rating, upper order batsmen showed balanced mesomorph, middle order batsmen were mesomorphic-endomorph, and lower order batsmen were found to be mesomorphic-ectomorph. No significant differences were also observed in the somatotype rating of the cricketers. Literature suggests that mesomorphic dominance is a key factor to success in the field of sports (2, 28). Batting in the short format of cricket is largely influenced by bursts of power and intermittent speed which is an inherent property of mesomorphy components. But, in this study, only Indian upper-order batsmen showed mesomorphic dominance and may have an advantage and support in games.

Movement pattern of different order batsmen during T20 matches: Time-motion analysis of T20 matches mainly focuses on comparing the intensity and T20 batting movement demands according to different batting positions. In this study, it was observed that lower-order batsmen covered significantly less distance and time in standing, walking, and jogging movements in the crease while batting in T20 matches than the upper-order and middle-order batsmen. Sholto-Douglas et al. (2020) studied the movement demands of the cricketers during the Big Bash League (T20 format) in Australia and found a trivial difference in the distribution of movement patterns during batting (31). Cricketers experience substantially different workloads and movement patterns depending on match strategy and their role within a particular game. In their report, Webster and Travill (2018) reported that a provincial batsman covers around 1469m during batting in a one-day match (37). However, batsmen in this study covered relatively shorter distances while batting compared to previous studies (25). It was also seen that standing made up the maximum amount of time (54.1 to 60.9%) while batting in T20 matches, whereas the maximum distance was covered by walking (68.5 to 73.3%). Results further showed that all groups of batsmen covered minimal distance and duration in sprinting during T20 matches. In T20 matches, batsmen intend to convert maximum balls into boundaries. However, continuous strike rotation also plays a key role in making a difference in the result. Petersen et al. (2010) monitored T20 players during simulated batting innings (BATEX) and reported that on average a batsman covered 2429 ± 606 m/h (25). Since T20 cricket is very popular nowadays and the increased significance, benefits (financial awards, prestige), and exposure (bigger crowds at grounds and millions of viewers on television) may help to explain why T20 batsmen put forth more effort and move more vigorously compared to other formats of cricket. Future research is required to identify whether batsmen playing in a different order in other formats of cricket like one-day and test matches similarly have different movement requirements and demands. Regardless of the reasons for these variations, conditioning coaches can utilize this information to learn more about the demands placed on their players while they play T20 matches.

HR response of different order batsmen during T20 matches: This study shows that the average HR of upper-order batsmen was significantly lower compared to middle and lower-order batsmen during T20 matches. Upper-order batsmen which also includes openers are commonly considered specialized batsmen, whereas middle-order batsmen are generally specified as all-rounders, and lower-order batsmen are mostly specialized bowlers. However, few cricketers who were recognized as 'big hitters' in the team are utilized in any batting order depending on the match scenario or necessities of the game. Researchers found that variation of HR during batting is fundamentally influenced by an internal physical and psychological association that depends on the match situation (8, 14, 21, 35, 36). During batting, along with the skills, intuition, hand-eye coordination, footwork, peripheral view imaging, selection of shots, and improvisation also plays a leading role (34, 36). These factors might have caused the lower HR of upper-order batsmen compared to others in this study, as upper-order batsmen are specialized in batting compared to middle and lower-order batsmen and they are specifically trained in batting in various situations (36). Middle-order batsmen also showed a significantly higher peak HR during batting than upper-order batsmen. The reason for average HR and peak HR differences between different order batsmen may be due to different total work duration (the total time spent in the crease) and intensity of their games in that specific duration. Generally, lower-order batsmen spend less period time in the crease and perform short high intensity efforts according to match demands.

Test cricketers need the endurance capacity to maintain physical performance over six hours and for several days, whereas an innings duration of a one-day cricket match is 3.5 hours (26) and a typical Twenty20 game lasts around 80 minutes. A substantial variation in the time spent in various THR zones during batting was observed in the study. We found that lower-order batsmen spent 71.4% in the high-intensity THR zone whereas the upper-order batsmen spent 16.9% of the time in it during batting. The batsman’s workload varies greatly depending on their batting order and the role within a particular match. Short bursts of high-intensity efforts along with psychological interface are the cause of exhibiting medium to high-intensity HR demands during batting (29). Stored phosphocreatine (PCr) and the glycolytic energy system is the main energy supplier to place the body into an oxygen-deficient state (27, 29). Adenosine triphosphate resynthesis, an oxidative energy system also plays a major role in PCr restoration and lactate oxidation during batting in the lower-intensity THR zone. HR kinetics of upper-order batsmen during batting in T20 matches were found to be relatively lower compared to others. Previous studies reported that HR escalates due to sympathetic over-activation and after a certain period of time rate of HR increment slows due to sympathetic-parasympathetic balance that comes from the psychological adjustment of the batsmen (38). However, this pattern does not corroborate with the HR response observed in this study. An increment was observed in the HR kinetics of the batsmen playing T20 matches.

As with any other applied research, the current study also has some inherent limitations like this study only included sub-elite T20 batsmen and a limited number of lower-order batsmen due to unavailability. Future studies need to be carried out on elite-level batters with a greater sample size. Although this study is unique in its nature as Indian T20 batsmen were assessed and movement patterns and physiological demand were monitored during the actual matches.

In conclusion, our study results have uncovered fascinating findings regarding the physical and physiological characteristics of different order batsmen in T20 cricket matches. Despite no significant differences in physical characteristics, we found that upper, middle, and lower order batsmen exhibited distinct somatotypes, with balanced mesomorph, mesomorphic-endomorph, and mesomorphic-ectomorph, respectively. Furthermore, the physiological and movement demands during T20 matches significantly varied among different batting order batsmen. Upper order batsmen predominantly spent time in the low-intensity THR zone, whereas lower order batsmen were mostly in the high-intensity THR zone during batting. This emphasizes the importance of customizing training drills and activities specific to each cricketer based on their batting order, which could improve their overall performance. Coaching staff and conditioning coaches can provide training drills and activities accordingly. As no research has specifically compared the physiological profile of different batsmen, and because the movement demands placed on cricketers are highly dependent on the type and nature of the game, it'll be interesting for the future studies to consider different types of cricket matches like test, one-day, and T20 and do more in-depth analyses of batsmen demand.

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