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'RESTING TOUCHER': A TIME AND MOTION ANALYSIS OF ELITE LAWN BOWLS

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ABSTRACT

Whilst numerous investigations have explored the physical demands placed upon competitive sportspeople from a wide array of sports little is known about the physical demands placed on lawn bowlers. The purpose of this study was to ascertain the movement activities of Australian representative singles and pairs players and to determine the frequency and duration of these activities. One match each of two male and two female players (one singles and one pairs player per gender) were videotaped during an international tournament. During playback of the videotaped matches (n = 4), a single observer coded the players' activities into five distinct categories (waiting, walking forward, walking backward, jogging and bowling) using a computerised video editing system (Gamebreaker™ Digital Video Analysis System). Field calibration of players over 30m for forward motions and 15m for the backward motion was performed to allow for the estimation of total distance covered during the match. Heart rate was monitored during each match. The duration of a match was found to be (mean ± SD) 1hr 28 ± 15mins. The total distance covered during each match was 2093 ± 276m. The mean percentage of match time spent in each motion was: waiting, 61.8 ± 9.3%; walking forward, 22.3± 5.6%; walking backward, 2.0 ± 0.4%; jogging, 1.1 ± 0.5%; and bowling, 8.5 ± 4.2%. Average heart rate was found to be 57 ± 7% of age-predicted HR_{max} with a maximum of 78 ± 9% of age-predicted HR_{max}. The results of this study suggest that playing lawn bowls at an international level requires light-moderate intensity activity similar to that reported for golf.

KEY WORDS: Frequency, mean duration, heart rate, energy expenditure.
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INTRODUCTION

The modern game of Lawn bowls has its origins in England early in the 13th Century. A similar game is reported to have been enjoyed by Ancient Egyptians, the Aztecs, North American Indians, and also in China and Polynesia. Lawn bowls is predominantly a game of skill but there is also a physical component necessary for its performance.

This is also true for other so called "target sports" such as archery, golf, shooting and ten-pin bowling. An analysis of golf participation indicated that over the course of an 18-hole round mean heart rate was 108 beats/min, equating to 35-41% of maximal oxygen capacity (Murase et al., 1989) although this intensity has been reported to increase with the age of the player (Brohman et al., 2004). Numerous other competitive sports have been analysed for the

physical component to investigate the demands placed on participants. Team sports such as rugby union (Duthie et al., 2005), soccer (Krustrup et al., 2005) and field hockey have been analysed by time and motion studies to elucidate the physical demands of playing the sport. Sporting officials from rugby league (Kay and Gill, 2003), soccer (D'Ottavio and Castagna, 2001) and rugby union (Martin et al., 2001) have also been the target of time motion analyses. The information obtained from previous time and motion studies has been used to tailor specific conditioning programs for participants and also to develop sport-specific field tests. No such investigation has been carried out for Lawn Bowls.

The sport of lawn bowls is played on a bowling green, a level grass covered surface with dimensions approximately 40m x 40m (Judson, 2004). A game of lawn bowls is played on a rink, a demarcated strip of a bowling green, denoted by pegs at either end, usually between 5.5 and 5.8 meters wide (Judson, 2004) allowing several games of lawn bowls to be played concurrently on the same green. Singles, pairs, triples and fours games are played in accordance with the number of players constituting a team. Specific rules are followed concerning the number of deliveries allowed each player and when play is to end and a winner emerge. Players, and teams, alternately deliver their biased bowls down the green towards a small white non-biased bowl called the jack with the aim of having as many bowls as possible closer to the jack than their opponent. One point is awarded for each bowl closer to the jack than any opposing bowls. The direction of play reverses for successive ends, each of which follows the sequence of laying a protective mat, delivering the jack and delivering the allowable number of bowls, in turn. The current format for international level competitive bowls sees matches played over 2 sets of 9 ends with 4 bowls per player for singles matches and 2 bowls per player for pairs and triples.

The work reported here analysed the movement activities of Australian representative singles and pairs players and obtained some preliminary data on the physical demands on players at this level of competition.

METHODS

Subjects

Four Australian representative lawn bowlers gave their informed consent to participate in this research. Two males aged 29 yrs and 26 yrs with body masses of 113 kg and 69 kg respectively and two females aged 44 yrs and 31 yrs with body masses 70 kg and 67 kg participated.

Stride calibration

Prior to filming a stride calibration was conducted to ascertain stride length and movement velocity during the motion categories of walking (forward and backward) and jogging. This calibration was done over a 30m distance for walking forward and jogging and 15m for walking backward. This information was used to estimate distance covered during the match.

Games analysis

The matches that were analysed were played at the Tri-Nations Cup tournament between Australia, New Zealand and Malaysia that was held in Melbourne (Darebin International Sports Centre) Australia between the 31st January and 2nd February 2006. 2 singles matches (1 men's and 1 women's) and 2 pairs matches (1 men's and 1 women's) were recorded for analysis. The skips of the pairs combinations were filmed and used for analysis. During matches the on-green motion of players was captured by a video camera (Panasonic Model No.NV-GS150GN, Matsushita Electrical Industrial Co. Ltd. Japan) with a moveable field of vision. The camera was positioned at the side of the green that was closest to the rink on which the match was being played. Player movement was followed for the duration of the match. Footage was recorded onto miniDV tapes (Panasonic DVM80, Matsushita Electrical Ind. Co. Ltd. Japan).

Player motion was subjectively characterised by an experienced operator while watching the video playback. A software analysis program (Gamebreaker™ Digital Video Analysis System, Sportstec Pty Ltd, Australia) was used to quantify each motion category. Video footage of the matches (n = 4) was viewed and concurrently characterised by activating motion category buttons when a motion started and deactivating them when that motion ceased. This allowed the duration of each individual motion to be logged. At the completion of the analysis an output was obtained that detailed each motion category. This output included, for each of the five motion categories, the motion frequency, total time of motion during the match, motion as % of total match time and mean motion duration.

Motion categories

Player motions were coded into five different categories and were defined as follows:

Waiting: motionless or milling around the head or behind the mat (includes such activities as
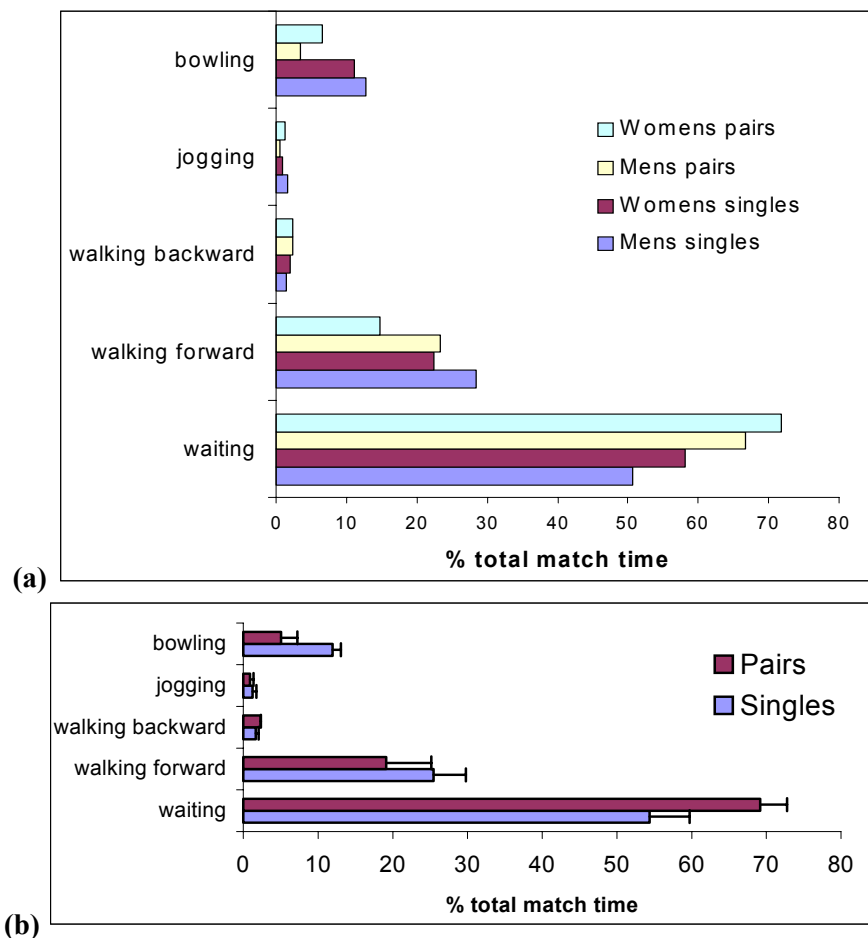
Figure 1. (a) Percentage of total match time spent within each motion category for each individual match; **(b)** Percentage of total match time spent within each motion category for combined singles (n = 2) and pairs (n = 2) matches. Displayed as means (±SD.).

picking up bowls, shuffling feet, organising bowls, filling out scorecard, pacing, waiting to bowl, watching own bowl, inspecting the head, watching opponents bowl, and getting a drink).

Walking forward: forward motion with both feet in contact with the ground at same time during some point in the gait cycle.

Walking backward: backward motion with both feet in contact with the ground at same time during some point in the gait cycle.

Jogging: motion with an airborne phase.

Bowling: motion involved in delivering a bowl.

Heart rate monitoring

Players agreed to wear a heart rate monitor during the matches that they were filmed playing. The equipment used for recording heart rate constituted wearing an elasticised transmitting strap around the chest and a watch on the wrist (Polar Model No.S610, Polar Kempo, Austria). Average heart rate was recorded for each 15 second period of match time. The raw data that was collected was converted to the percentage of age-predicted maximum heart rate (HR_{max}). Age-predicted maximum heart rate was calculated using the equation $HR_{max} = 220 - $ age.

Reliability data

Player motion from the first set (9 ends) of each match (n =4) was analysed at three different times over a 10 day period to establish intra-tester reliability. The average duration of this footage was 44 ± 2.5min. These times were Day 1 (1), Day 4 (2), and Day 10 (3). The viewing order of the four matches was randomised using a Latin Square design. A bivariate correlation (Pearson Correlation – 2 tailed) analysis was performed on the data (frequency and mean duration for all 5 motion categories). Intra-tester reliability was found to be within 95% confidence intervals.

Data analysis

The differences in motion frequency, duration and distance (if applicable) between gender and between singles and pairs were examined. All results are reported as means±SD.

Table 1. Frequency and mean time for each motion category for all matches combined (n = 4), singles (n = 2) and pairs (n = 2) matches. Results are presented as means (±SD).

| Motion	Frequency (n)			Mean duration (s)		
	All	Singles	Pairs	All	Singles	Pairs
Waiting	117 (39)	143 (35)	90 (20)	30 (12)	20 (1.0)	41 (2)
Walking forward	107 (20)	124 (6)	90 (8)	11 (1)	11 (.5)	11 (2)
Walking backward	27 (8)	25 (6)	29 (12)	4 (1)	4 (.5)	5 (1)
Jogging	9 (4)	9 (4)	10 (5)	6 (2)	7 (2.0)	5 (1)
Bowling	56 (28)	79 (16)	33 (4)	8 (3)	8 (1.0)	8 (5)

RESULTS

Match times and motion categories

Average match time was 1hr 28±15mins with 61.8 ± 9.3% of this time spent waiting, 22.3 ± 5.6% walking forward, 8.5 ± 4.2% bowling, 2.0 ± 0.4% walking backward and 1.1 ± 0.5% jogging. Individual match times for men's singles, women's singles, men's pairs and women's pairs were 1hr 15mins, 1hr 39mins, 1hr 14mins and 1hr 42mins respectively. While the difference between average match times for gender was quite large (1hr 15mins for men vs. 1hr 41mins for women) when the average match time for singles and pairs matches were compared these were quite similar, being 1hr 27mins and 1hr 28mins respectively. The percentage of total match time within each motion category for each match (n = 4) and also for combined singles (n = 2) and pairs (n = 2) matches is presented in Figure 1.

The frequency of motion occurrence varied greatly for some motion categories and very little for others. The frequency of waiting (143 vs. 90), walking forward (124 vs. 90) and bowling (79 vs. 33) motions were the standout differences between singles and pairs matches while walking backward (25 vs. 29) and jogging (9 vs. 10) motions were similar in number. Mean time spent in each motion was very similar when singles and pairs matches were compared with the exception of waiting (20s vs. 41s). These results are presented in Table 1.
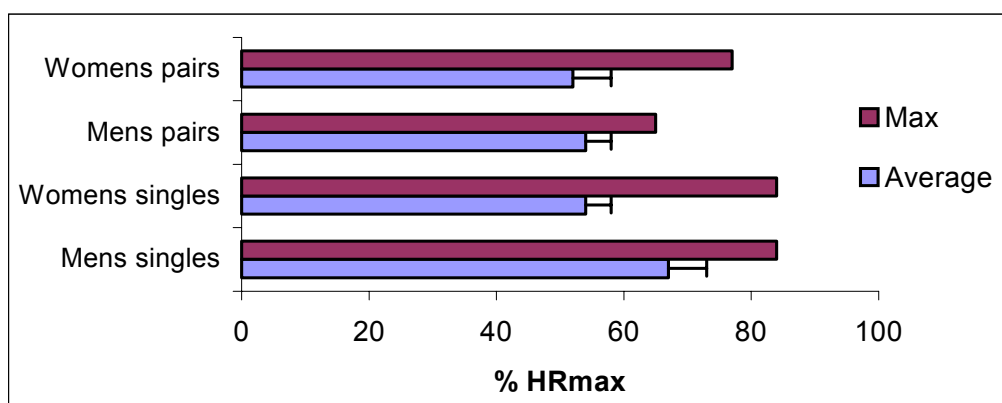
Distance covered during the match

As seen in Figure 2, the average distance covered during a match was 2093 ± 276m.

The majority of this was in the form of forwards walking (1792 ± 327m). Jogging contributed 7.5 ± 4% of the total distance traveled, or 157 ± 85m. Each jogging repetition was

(a)

(b)
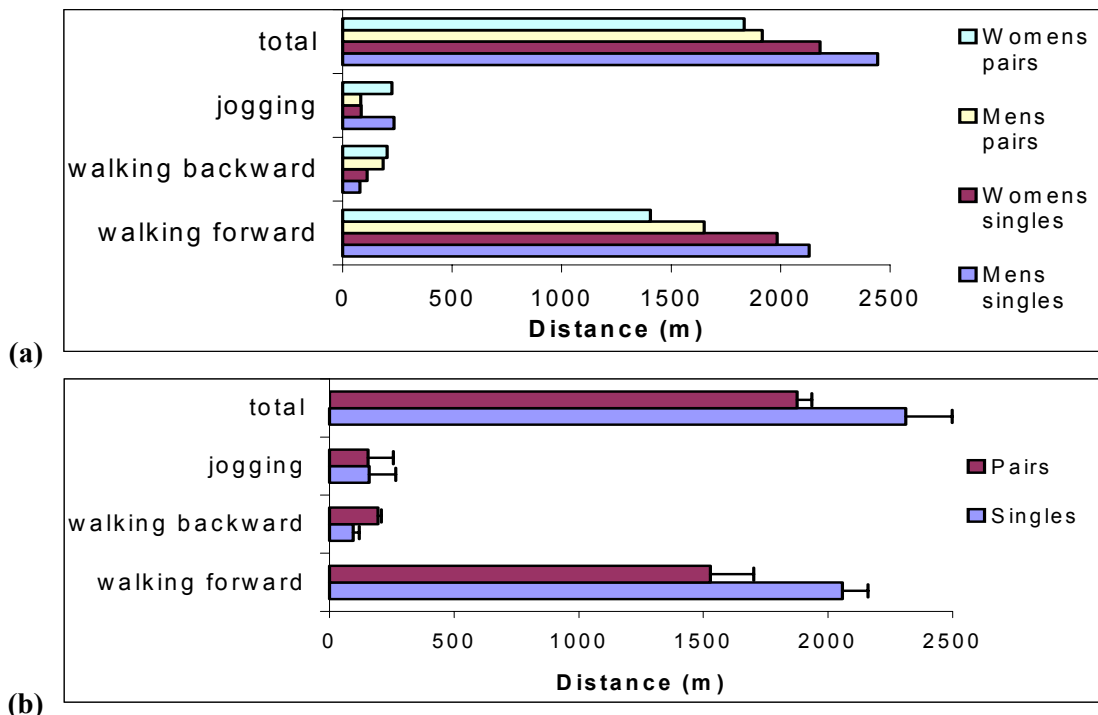
Figure 2. **(a)** Total distance and distance covered during separate motion categories for each individual match; **(b)** Total distance and distance covered during separate motion categories for the combined singles and pairs matches. Displayed as means (±SD).

Figure 3. Average and maximum heart rates during each individual match. Average heart rates are presented as means (±SD).

approximately 16m in distance. The distance covered in each motion category during each match (n = 4) and also for combined singles (n = 2) and pairs (n = 2) is presented in Figure 2.

Heart rate during the match

The average heart rate recorded during the four matches was found to be 107 ± 15 bpm. This equated to 57 ± 7% of age-predicted HR_{max}. The maximum heart rate that was observed during a match was 78 ± 9% of age-predicted HR_{max} equating to 144 ± 13 bpm (highest recorded heart rate was 161 bpm). Heart rate for each match (n = 4) is presented in Figure 3. Figure 4 illustrates the percentage of match time spent in several percentages of age-predicted HR_{max} brackets during the four matches analysed.
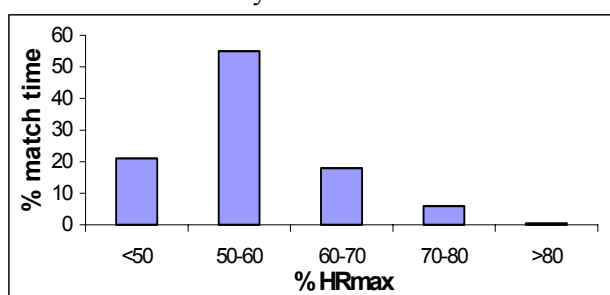
Figure 4. The average percentage of match time accounted for in several percentages of age-predicted HR_{max} brackets in the four matches analysed.

DISCUSSION

During the four matches analysed at the 2006 Tri-nations Cup Tournament in Melbourne it was found that the players spent most of their time engaged in what could be termed preparatory activities either behind the mat or at the head. In this study it was found that approximately 65% of match time was accounted for in this way. The remaining time was spent walking (≈25%), jogging (1%) and bowling (≈9%). The average duration of the matches was approximately 1½hr. On average players covered just over 2000m during the match. The majority of this distance can be attributed to walking forward (≈85%). Average heart rate during the matches was approximately 60% age-predicted HR_{max} with the maximum recorded heart rate being close to 80% age-predicted HR_{max}.

Although the total match times were very different when men's and women's matches are compared, the time taken to play the first set (9 ends) was not markedly different. Men took 43min to complete the first 9 ends while women required 45min. The explanation for this total match time difference is the nature of the games filmed. Both men's games were completed in 2 sets with the number of ends totaling 16 for singles and 15 for pairs whilst the women's matches comprised 2 sets and a tie-break for singles (total of 21 ends) and 2 sets for pairs (total of 18 ends). Therefore, men played 31 ends in a total time of 149min and women played 39 ends in 201min. This equates to 4:48min per end for men and 5:09min per end for women. To complete an 18 end match (2 sets of 9 ends each) it can be predicted that it would take women 6:18min longer than men. To put this in real terms, the men would finish while the women still had a little over an end to complete. Amongst bowling circles it often stated that women take longer to complete a match than men, tending to spend longer in discussion about tactics and inspecting the head. This closeness of predicted finishing times does not appear to support the belief that women are much slower players than men. Compared to women the men spent 30% more match time in the motions of walking and jogging. This is illustrated when distance covered per end is compared. Men covered an average of 70m per end and women 51.5m, a 35% differential.

Total match time was not found to be different when singles and pairs were compared however when the first 9 ends were analysed pairs took an average of 4min longer than singles. Singles players covered on average 500m more than their pairs counterpart (2 312 m vs. 1 876 m), this difference was primarily due to the amount of distance traveled in walking forward (2 057m vs. 1 528 m). Interestingly, the skips of the pairs combinations covered more than twice the distance walking backward than the singles players, 194m vs. 95 m. It was observed during the matches that after discussing tactics at the head or mid-rink that the skip of the pairs would take paces backward to either finish the conversation with their playing partner or to have a longer look at the formation of the head. This may explain the vast difference in distance covered in the motion of walking backward. Jogging was not found to be different (160 m vs. 154 m) and appeared to be very individual with singles players recording distances of 235m and 85m and pairs 82m and 225m (men and women respectively). Differences were observed in the % of match time spent in the motion categories of waiting (55% vs. 70%), bowling (12% vs. 5%), and walking forward (25% vs. 19%). Additionally, the frequencies of these same motions were also found to be different. Waiting (140 vs. 90), walking forward (124 vs. 90) and bowling (78 vs. 32). Due to the mean times of the motion categories of bowling and walking forward being similar the difference in the frequency explains the difference in the % of match time each one accounted for. Although singles players had 50 more occurrences of waiting than the skips of the pairs combinations the difference in the mean time of this motion category (20s vs. 41s) explains the % match time difference observed for this motion.

During the matches analysed (n = 4) a little more than 2000m was covered in 90 minutes. This gives an average movement velocity over the duration of the match of approximately 1.5 $km·h^{-1}$. However, 65% of this time was spent in the motion category of waiting. Walking, jogging and bowling accounted for the remainder of this time. Bowling is a relatively stationary event and seeing this accounted for approximately 9% of match time the approximate 2000m distance that was covered in a match was realistically done in 26% of total match time, or 23½min. This equates to an average movement velocity of approximately 5km/h. The motion category of jogging accounted for a minor portion of total distance covered (7.5%) with each bout lasting approximately 6s, covering 16m at an average velocity of 9.6km/h. Overall, a lawn bowls match would rate as a light-moderate intensity activity. Energy expenditure is estimated to be approximately 260kcal per match, roughly equivalent to the energy required to complete a 40min brisk walk (Whitney and Rolfes, 2002).

Heart rate was found to remain relatively stable throughout each match at an average of 60% age-predicted HR_{max}. In fact, 55% of match time (approximately 50 min) was spent with heart rates between 50-60% age-predicted HR_{max}. A further 16min (or 18%) of match time was played at between 60-70% age-predicted HR_{max}. The combination of these two periods of match time (accounting for more than 70% of match time or approximately 60min) would roughly equate to exercising at 35-40% VO_2max (Swain et al., 1994). According to American College of Sports Medicine (2000) 60 minutes of activity at this exercise intensity would not be an effective weigh-loss orientated exercise session and would provide for only minimal cardiovascular and health related benefits. The maximum heart rate observed was on average close to 80% HR_{max}. Whilst this top end heart rate was only realised very briefly during each match it may pose problems to those suffering from cardiovascular complaints such as hypertension.

Golf participants covered 10km during an 18-hole round (Thériault and Lachance, 1998). Goalkeepers in soccer have been reported to cover around 4km per match (Stolen et al, 2005), rugby union referees 8.5 km (Martin et al, 2001) and rugby league referees 6.7 km (Kay and Gill, 2003). A total match distance of 10km was covered by elite female soccer players (Krustup et al, 2005). These values are all substantially greater than the 2 km observed in this study.

Super 12 rugby union players spent approximately 40% of match time standing, 38% walking and 16% jogging with forwards engaging in static exertion 10% of total match time (Duthie et al, 2005). Elite female soccer players spent an average of 16%, 44% and 34% of match time in the motions of standing, walking and jogging respectively (Krustup et al, 2005). While the combination of the three motion categories (standing, walking and jogging) is approximately equivalent to this study the contribution that each makes to the total is vastly different. Interestingly the 10% match time spent in static exertion reported by Duthie and co-workers (2005) in Super 12 forwards roughly parallels the 9% of match time spent bowling in this study, another static activity.

As could be predicted, average heart rates during play for all team sports are substantially higher than that observed during this study. Krustup and colleagues (2005) investigated 14 elite female soccer players and reported average and maximal heart rates of 87% and 97 % of HR_{max} respectively.

During a round of golf it has been reported that younger players spend approximately 6% of playing time at a high intensity while 18% of playing time is at or below 50% HR$_{max}$ (Broman et al, 2004). These values are similar to that observed in this study and with the average age of participants in the current study being similar to that of the work by Broman and co-workers (2004) it appears that the games of golf and lawn bowls may share a similar intensity.

CONCLUSIONS

The time-motion analysis for movements by players in the sport of Lawn Bowls has been investigated for the first time. The majority of match time was spent in a waiting or preparatory activity (65%) with the next most time consuming activity being forwards walking (≈25%). The average heart rate was 107 ± 15 bpm or 57 ± 7% of age-predicted HR$_{max}$. A little more than 2000m was covered during the match with the vast majority (85%) of this total distance being forwards walking. Overall, Lawn Bowls appears to require light-moderate intensity activity and appears to be similar to the physical demands of golf.

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KEY POINTS

- The duration of a lawn bowls match played in sets play was 1hr 28±15mins.
- The majority (65%) of this time was spent in the motion category "waiting".
- Players covered more than 2000m during a match with the vast majority (85%) in the form of forward walking.
- The average heart rate was 107 ± 15 bpm or $57 \pm 7\%$ of age-predicted HR_{max}.
- The game of lawn bowls requires light-moderate intensity activity and appears to be similar to the physical demands of golf.

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