Cardiovascular Response to Recreational Hockey in Middle-Aged Men

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The present study examined the hemodynamic response to recreational pick-up hockey relative to maximal exercise testing in middle-aged men. A total of 23 men with a mean age of 53 ± 7 years were studied. Graded exercise testing on a cycle ergometer determined maximal oxygen consumption, blood pressure (BP), and heart rate (HR). Ambulatory BP and Holter electrocardiographic monitoring was performed during one of their weekly hockey games (mean duration = 45 ± 7.2 minutes): for "On-Ice" responses (PLAY; data recorded while standing immediately after a shift; 8.0 ± 1.4 shifts per game) and during seated recovery (BENCH), 15 minutes after the game. On-Ice HRs and BPs were significantly higher than values obtained during maximal cycle exercise, respectively (HR 174 ± 8.9 vs 163 ± 11.0 beats/min) (systolic blood pressure 202 ± 20 vs 173 ± 31 mm Hg; p <0.05). Both systolic and diastolic blood pressures decreased significantly throughout the duration of the game, whereas HR increased from 139 ± 20 to 155 ± 16 beats/min during the game. The myocardial oxygen demand (myocardial time tension index) increased significantly during PLAY concurrent with a decrease in estimated myocardial oxygen supply (diastolic pressure time index), with the endocardial viability ratio during PLAY demonstrating a significant decrease during the third quarter of the game (1.25 ± 0.24) versus the first quarter (1.56 ± 0.30), which remained depressed 15 minutes post-game (p <0.05). In conclusion, recreational pick-up hockey in middle-aged men is an extremely vigorous interval exercise with increasing relative intensity as the game progresses. Hockey elicits peak BPs and HRs that can exceed values observed during maximal exercise testing and is characterized by progressive increases in myocardial oxygen demand and lowered supply during PLAY and BENCH time. Given the progressive and high cardiovascular demands, caution is warranted when estimating the cardiovascular demands of hockey from clinical stress testing, particularly in those whom coronary reserve may be compromised. **(Am J Cardiol 2017;119:2093−2097)**

Increased concern exists about adverse responses to intensive exercise, particularly in the "weekend warrior" who exercises infrequently and as a result may have less cardioprotection than subjects engaged in regular and sustained vigorous physical activity,[1] which alone acutely increases risk of an adverse cardiac event above that expected at rest.[2] Anecdotal reports of sudden cardiac deaths during or shortly after recreational "pick-up" hockey in middle-aged men are widespread, but incidence rates are unknown. Limited data in this cohort indicate that hockey may elicit heart rates exceeding 90% of predicted maximal heart rate (HR_{max}).[3] Under these conditions, the myocardial oxygen supply/demand relation, particularly in the presence of known or occult heart disease, may be challenged uniquely.[4,5] Measures of heart rate (HR) and blood pressure (BP) would provide a more complete understanding of the relative cardiac "cost" of pick-up hockey in this age group. Therefore, the purpose of this study was to examine the hemodynamic effects of a full game of recreational hockey in middle-aged men, including patterns observed during exertion and rest while on the bench. We hypothesized that systolic blood pressure (SBP) and HR responses during hockey progressively increase during the game, approaching values seen during maximal exercise testing, and that estimated myocardial oxygen demand would increase concurrent with diminished supply.

Methods

A total of 23 men aged 40 to 65 years were recruited for the study from men's recreational "pick up" hockey games by postings at local rinks and by word of mouth. All participants completed informed consent, with all experimental procedures approved by the University of Toronto's research ethics board. Participants were then screened by interview to exclude a history or symptoms of cardiovascular disease, hypertension, or use of cardiovascular medications. Baseline measures of height (cm) and weight (kg), BP at rest, and maximal exercise testing were performed on a separate day but within 2 weeks of cardiovascular

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monitoring during hockey. Seated measures of BP and HR were averaged from 5 consecutive readings in a quiet room (BpTRU, Coquitlam, Canada) following recommended procedures.[6]

Maximal oxygen consumption (VO_2 peak) was determined by direct gas exchange (Moxus; AEI Technologies, Pittsburg, California) using an electronically braked cycle ergometer, as previously described.[7] Criteria confirming a maximal effort included a plateau in VO_2 or attaining a respiratory exchange ratio >1.15 and age-predicted maximal HR, which was monitored continuously (Polar RS800, Kempele, Finland) with BP_{peak} measured on the right arm by the oscillometric technique using a semi-automated motion-tolerant monitor (Tango M2; Suntech Medical, Morrisville, North Carolina) with the arm relaxed.

Cardiovascular monitoring during hockey occurred in one of 2 indoor arenas with similar environmental conditions, between November and February (6 to 10 P.M.). Ambulatory monitoring was established 20 to 30 minutes before the game as participants dressed and continued throughout the on-ice warm up (10 minutes), the game (45 to 55 minutes), and recovery period in the dressing room (15 to 20 minutes). A 3-lead electrocardiogram (ECG) was obtained by a Holter recorder (Holter DR200/HE; NorthEast Monitoring, Maynard, Massachusetts), with data analyzed for frequency of any ectopic beats and segmental and interval disturbances using proprietary software. BP was recorded using a motion-tolerant ambulatory, automated BP monitor (Accutraker II; SunTech Medical), secured on the right arm under the padding and player's jersey. This device has been validated against intra-arterial measures.[8]

During the game, "on-ice" (PLAY) measures of BP and a time marker were initiated immediately on the participant returning to the bench door (within 3 seconds), whereas subjects remained at standing position with feet shuffling back and forth. The total time required to complete BP measurements was approximately 45 seconds. Subjects then assumed a seated position (BENCH) with another measure completed after 60 seconds. Each player's position, shift number, and duration were recorded. Because pick-up hockey is unregulated with varying attendance each week, a wide variation in both the duration of shifts and bench time was expected. To account for this and to facilitate statistical analysis of trends, data from each game were binned into 4 time segments, each representing 25% of the game duration for each participant.

Myocardial oxygen demand was estimated using the modified time tension index (MTTI)[9] from the BP and HR data recorded using the equation: $MTTI = SBP \times \sqrt{HR}$, which has been correlated ($r = 0.80$) to direct measures of myocardial oxygen consumption (MVO_2), particularly when contractile state is elevated during exercise.[4] The diastolic pressure time index (DPTI) was also calculated as: (DBP-LV diastolic BP) × duration of diastole, with LB diastolic BP assumed to be 5 mm Hg.[10] Diastolic duration was estimated from the Holter ECG, magnified 10× on paper, defined as the mean of 3 consecutive time intervals between the end of the QRS complex to the end of the P-wave. The intra-observer reliability was determined in a blinded fashion on subset of 7 randomly selected participants, with an intraclass correlation coefficient of 0.99. The endocardial viability ratio (EVR) was calculated as an index of myocardial oxygen supply and demand, using a modified equation, where $EVR = DPTI/MTTI$.[4] For any given BP measurement, the HR corresponding to 15 seconds after the onset of inflation of the cuff was used for analysis of diastolic duration, to account for the cuff-inflation time. All BP measures were temporally aligned to the ECG data for determination of HR from marker events, and a rolling average of data was then determined for each quartile of the game.

All endpoints were compared at intervals throughout the game representing pre-game, on-ice (PLAY), bench sitting (BENCH), and post-game recovery using a repeated-measure ANOVA with least-squares post hoc analysis. Individual *t* tests with Bonferroni correction were used to compare maximal cardiovascular endpoints from maximal exercise testing and the highest recorded values during the hockey game. All data were considered significant at $p < 0.05$.

Results

All subjects completed the study without adverse responses, with key subject characteristics results presented in Table 1. None were taking cardiovascular medications or had known chronic diseases. Maximal exercise testing to exhaustion was completed in all subjects, with all achieving an respiratory exchange ratio >1.15; the mean HR_{max} achieved was 95% of the predicted maximal value,[11] with the mean VO_{2peak} within the 40th to 50th percentile for their age group.[12]

Peak HR, SBP, and DBP obtained during PLAY were significantly higher than those obtained during graded exercise testing (Table 1; $p < 0.05$), with values obtained at all time points similar regardless of player position. The mean duration of the hockey games (excluding light warm-up) was 45.5 ± 7.2 minutes. A wide variation existed for the number (mean = 2.1 ± 0.5) and duration (mean = 150 ± 30 seconds) of shifts per quartile; this was also the case for BENCH durations (mean = 140 ± 12 seconds), and in both cases, no differences existed between quartile or based on player position (defense vs forward). Mean HRs during PLAY for the entire game was 149 ± 16 with a mean bench HR of 126 ± 19, yielding an overall (PLAY and BENCH) mean HR of 137 ± 22 beats/min. Data from each quartile of PLAY and BENCH recordings are presented in Figure 1. As expected, the mean HR during bench time was lower than PLAY values throughout the game (Figure 1, $p < 0.05$) with a progressive upward drift of HR ($p < 0.05$) observed for both PLAY and BENCH values. The SBP (Figure 1) during PLAY reached the highest levels after the second shift early in the game and thereafter progressively decreased ($p < 0.01$); a similar pattern occurred for SBP during BENCH time points ($p < 0.05$) which were similar to PLAY values at any time point. The DBP (Figure 1) was elevated above pre-game levels during the first quartile of the game, decreasing significantly ($p < 0.05$) for both PLAY and BENCH values as the game progressed, remaining above pre-game values.

The MTTI (Figure 1) during PLAY increased significantly above resting levels, remaining elevated throughout the game and higher than BENCH recordings, which failed to return to pre-game (rest) values until the post-game. The DPTI (Figure 1) decreased from the onset of the game