G-Force Exposure and Functional Recovery in High School Ice Hockey Players

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ABSTRACT

PURPOSE: To measure G-force exposure in games and practices of high school hockey players over the course of 1 season and record weekly functional recovery.
METHODS: 6 players from a high school hockey team (age 15±1.2 yr, height 1.8±0.1 m, mass 68±12.0 kg) were instrumented with accelerometers during 12 games and 17 practices over 11 weeks. Players expected to have the most on-ice time were selected for the study. A small triaxial accelerometer (mass 5 g) with a flash memory chip data logger (Axivity, Newcastle, UK) was fitted to the players' garter belts. Data were acquired at 100 Hz. Resultant G-force was calculated from the raw accelerometer data collected in all 3 planes (scale ±16G). G-force data were analyzed by quantifying the time spent above 1G, 2G, etc. up to >8G. Players completed weekly functional recovery questionnaires on weeks 2-11 (0-30 scale;; <20 = impaired recovery). ANOVA with Bonferroni corrections was used to compare G-force exposure in games vs. practices.
RESULTS: Resultant G-force was ≤ 2G 98% of the time in games and practices. Despite longer duration for games versus practices (104±15 min vs. 85±24 min P<0.01), differences in G-force exposure were only apparent at high G-force thresholds (P<0.01). Weekly functional recovery score was consistent across the season (22.6±3). Impaired recovery (<20) was evident in 8 of 60 (13%) recovery questionnaires. G-force exposure was not related to indices of recovery.
CONCLUSIONS: Differences in G-force exposure between games and practices at high (>4G) but not low (>2G) G-force thresholds likely reflects greater physical contact in games versus practices. Functional recovery data indicated that players mostly had adequate recovery time. This technology and method of quantifying G-force exposure may prove useful in monitoring the physical stresses imposed on ice hockey players. *(email mchugh@nismat.org)*

INTRODUCTION

Figure 1: Triaxial accelerometer

Accelerometers (Fig. 1) are being used increasingly to document impact forces in contact sports, particularly with regard to head injuries and concussions (Urban et al 2013; Crisco et al 2010; Duma et al 2005; Cobb et al 2013; Daniel et al 2012; Eckner et al 2011; Duma and Rowson 2009; Crisco et al 2004; Naunheim et al 2000). Accelerometers can also be used to quantify the whole body physical stress on athletes in contact sports and sports with sudden directional changes (Sullivan et al 2013; Boyd et al 2011; McHugh et al 2014).

There has been limited research using accelerometers to quantify whole body physical stresses imposed on athletes in sports. The primary purpose of this study is to use triaxial accelerometers to record G-force exposure in high school ice hockey players during all games and practices over the course of a season. A secondary purpose was to document functional recovery of the athletes on a weekly basis and determine if high G-force exposure results in impaired functional recovery.

METHODS

Experimental Protocol

G-force:
A small triaxial accelerometer (mass 5 g) with a flash memory chip data logger (Axivity, Newcastle, UK) was fitted to the center-rear of the padding in the players' shorts (anatomically slightly superior to the lumbar spine to approximate the players center of mass in the sagittal and frontal planes). Data was acquired at 100 Hz (scale ±16G). Sensors were fitted in the pads of six players (age 15±1.2 yr, height 1.8±0.1 m, mass 68±12.0 kg) for 12 games and 17 practices over 10 weeks. The sensors were removed every week to download the data (Fig. 2) and reapplied after download (data logger can record continuously for approximately 2 weeks at 100 Hz).

The absolute values for G-force data in all 3 planes of motion (Fig. 3) were summed to provide a total G-force for every 1/100th of a second. Then the G-force exposure was quantified based on total time at the following thresholds:
>2G (low load)
>3G
>4G (high load)
>5G, >6G, >7G, and >8G.

METHODS cont.

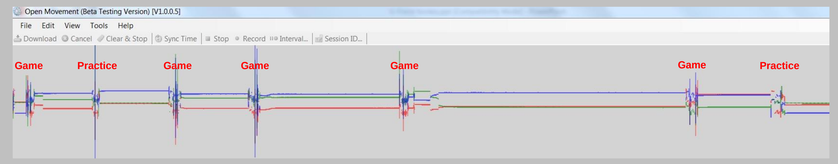

Figure 2: Raw accelerometer data from a player over a one week time period showing seven bouts of activity.

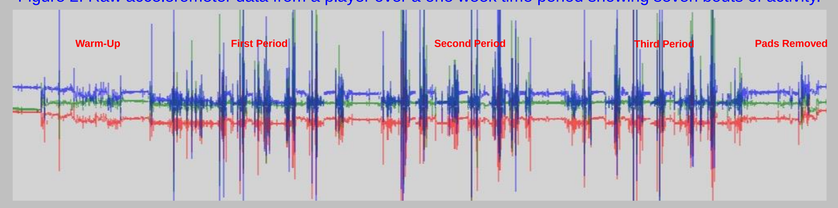

Figure 3: Raw accelerometer data from a player during a game, showing warm up and three periods separated into shifts. The vertical plane is red, frontal plane is green, and sagittal plane is blue in standing.

Functional Recovery and Performance Questionnaire:
On a weekly basis (weeks 2-11) each instrumented player was asked to complete a subjective questionnaire designed to assess functional recovery and performance status. Players recorded responses (Strongly disagree, Disagree, Neutral, Agree, Strongly agree) to the following statements:

FUNCTIONAL RECOVERY AND PERFORMANCE STATUS QUESTIONNAIRE

NAME: DATE:

Please answer each of the questions below with respect to how you have felt over the last 7 days. Please check the appropriate box. Also please provide details on the number of games and practices you participated in.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I slept well at night during the last week					
I have been looking forward to my workouts					
I am optimistic about my future performance					
I have been feeling vigorous and energetic					
My appetite has been great					
I have had little muscle soreness					

	GAMES	PRACTICES
Please indicate the number of hockey games and practices you have participated in in the last 7 days		
Please indicate the number of games or practices you have missed in the last 7 days and the reasons for missed games or practices.		

Reason For Missed Game
Reason For Missed Practice

Scores for each of the 6 statements ranged from 1=Strongly disagree to 5=Strongly agree. The maximum possible score was 30 (6x5). Athletes scoring 20 or above were deemed to be functionally recovered, while athletes scoring less than 20 were deemed to have inadequate functional recovery.

Statistical Analysis

The primary measure of interest was duration of high-load exposure. Game-to-game, and practice-to-practice fluctuations in high-load exposure were mapped for the course of the season in addition to cumulative high-load exposure. Duration at high load in the prior week was compared between players functionally recovered and those with inadequate functional recovery using independent t-tests. ANOVA with Bonferroni corrections was used to compare G-force exposure in games vs. practices. The season lasted 10 weeks, thus, there were 60 individual functional recovery assessments (6 players weekly for the duration of the season).

RESULTS

Resultant G-force was ≤ 2G 98% of the time in games and practices, with little activity >4G. Based on these distributions analyses were subsequently made on time spent at greater than 2G (Low), or greater than 4G (High).

	>2G	>3G	>4G	>5G	>6G	>7G	>8G
Games (s)	74.63	16.21	6.02	2.97	1.69	1.06	0.71
Practices (s)	63.19	11.09	3.25	1.35	0.69	0.41	0.26
% Difference	15%	32%	46%	55%	59%	61%	63%
P-value	0.89	0.2	0.05	0.01	0.001	0.001	0.001

Figure 4: Distribution of time (s) at different G-forces in games and practices. These data were used to categorize Low (>2G), and High (>4G) G-force exposure.

Despite longer duration for games versus practices (104±15 min vs. 85±24 min P<0.01), differences in G-force exposure were only apparent at high G-force thresholds (P<0.01). Weekly functional recovery score was consistent across the season (22.6±3). Impaired recovery (<20) was evident in 8 of 60 (13%) recovery questionnaires. G-force exposure was not related to indices of recovery.

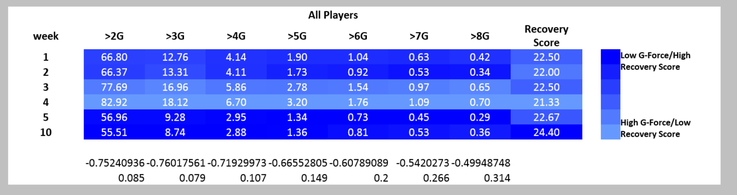

Figure 5: Differences in G-force exposure at >2G, >3G, >4G, >5G, >6G, >7G, and >8G and recovery score at week 1, 2, 3, 4, 5, and 10. Dark blue color indicates low G-force exposure (s) and high recovery score, light blue color indicates high G-force exposure (s) and low recovery score. Although G-force exposure was not related to indices of recovery, in our limited sample, indices of recovery trended towards significance at >2G and >3G.

DISCUSSION

Accelerometry analysis was effective in distinguishing game versus practice differences only at high G-force (>4G) in ice hockey players (Fig. 4), indicating greater physical contact in games versus practices. The lack of differences at low G-force (>2G) exposure may reflect similarities in physiological stress in games and practices. Interestingly, high G-force exposure was greater for practice vs. games in Gaelic and Australian rules football (McHugh et al 2014; Boyd et al 2013). Although G-force exposure was not related to indices of recovery, in our limited sample, indices of recovery trended towards significance only at the >2G and >3G threshold but not at the high G-force threshold (Fig. 5). Functional recovery data indicated that players mostly had adequate recovery time (87%).

•This technology and method of quantifying G-force exposure may prove useful in monitoring the physical stresses imposed on ice hockey players.

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