

The Physical Demands of Hockey

A Summary of GPS Findings with the NZ Men's BlackSticks

Part 1 - Introduction

GPS data has been collected during a number of matches involving the NZ Men's Blacksticks over the last 24 months. The 122 sets of data obtained now provide information on distances covered by players, running speeds and work rate throughout the game. This information is being

actively used within the men's BlackSticks programme to identify areas of weakness and opportunity in match-play and also to help select appropriate fitness testing and fitness training procedures. A summary of data as at 30th June 2006 is presented below (please refer to table 1) with explanation and discussion following.

Table 1: Summary of GPS Variables in NZ Men's Elite Hockey

	Fullback	Half	Centre Half	Inside Forward	Striker
Game Distance (m)	6951	6709	8304	7471	7166
Normalised Game Distance (m)	7808	8553	8639	8870	8806
Zone 5 Dist (m) 16-20km/h	438	546	794	702	693
Zone 6 Dist (m) 20km/h+	194	310	385	291	418
Total HI Distance (m) Zone 5+6	632	856	1179	992	1111
Total Normalised HI Dist (m)	756	1088	1225	1185	1381
Top Speed (km/h)	25.9	26.8	26.6	26.4	27.9
Short Sprints # (1-2s)	9.7	12.2	16.7	13.3	18.6
Med Sprints # (3-4s)	3.9	5.4	6.2	6.4	7.4
Long Sprints # (5s+)	1.3	2.4	3.0	2.1	3.3
Total Sprints #	14.8	20.0	25.9	21.8	29.3
Number of Data Sets	23	24	11	25	39

*All values are averages

Explanation of Data Collection Process

GPS or global positioning system devices that are now common-place in boats and cars have been reduced in size and modified sufficiently to allow them to be worn by athletes in sports such as Australian Rules Football, Soccer and Hockey. The unit is the size of a small cell phone and is worn in a harness/back-pack that sits between the shoulder blades (please refer to figure 2). The device records position every one second and uses this position coordinates to calculate speeds and distances. Although the data is relatively accurate, the one-second sample interval means that there is a small amount of error and very

small player movements are not always recorded. A recent research project carried out by the Australian Institute of Sport calculated that the approximate error associated with using these GPS devices in games was 4% (GPS tended to over-estimate total distance). Since July 2004, GPS data has been collected using the Men's Blacksticks players in a variety of matches. Eleven squad matches, four international test matches (played in Europe and Fiji in 2005), and five Commonwealth Games selection matches (played against the Tasmanian NHL team) are included for a total of 122 sets of data.



Part 2 - Explanation of GPS Variables

Although a broad range of information is output by the GPS software there are some key variables that have been isolated and used to assess physical performance. These key variables include game distance, distance covered at various intensities, and the number of sprints performed.

Game Distance

This refers to total distance covered by a player during a game (male hockey players cover 7-11km during a 70-minute game). This compares to 10-13km in soccer, 12-18km in Australian Rules and 6-10km in Rugby. A secondary variable related to total distance covered is the decrement between the first and second halves (it is common for players to cover 5-10% less distance in the second half). A large decrement in distance covered usually results from a lack of fitness or a slowing of the game due to a one-sided score-line.

Distance Covered within Speed Zones

Running speed is calculated throughout the game so that it can be determined how much time and distance was spent at different intensities. The speed zones are as follows:

Table 2: Speed Zones

Speed Zone	Movement Speed	Intensity/Activity
Zone 1	0-2km/h	Standing Still
Zone 2	2-6km/h	Walking
Zone 3	6-12 km/h	Jogging
Zone 4	12-16km/h	Running
Zone 5	16-20 km/h	Fast Running
Zone 6	20+km/h	Sprinting

High Intensity Distance

After collecting data for approximately 12 months (both with Hockey and previously with Soccer) it became apparent that distance covered at high intensity was much more important than total game distance. This variable (high intensity distance) has therefore become the primary BlackSticks index of work rate. High intensity distance equals the sum of zones 5 and 6 (all distance covered at 16km/h or faster).

Normalised Game Distance, Normalised High Intensity Distance and Normalised Total Sprints

To allow for comparison between data sets (either between players in different positions, players in



Figure 1: GPS Device (usually worn under the shirt). Picture from NZ Herald.

the same position or the same player in multiple games) it is necessary to convert all data to 70 minutes. As most players (particularly those in the midfield and forwards) tend not to play 70 minutes per match the data is scaled upwards e.g. if a player is on the field for 55 minutes then his data is multiplied by 70/55 to give normalized values. Clearly this is not fair to those who actually play 70 minutes but it is necessary to allow for comparison.

Sprints

When using this GPS system a sprint is recorded every time the player runs at a speed of 20km/h or faster (this speed threshold can be set at any level but after a period of experimentation a value of 20km/h was chosen). The software then records how long (both time and distance) the player stays above 20km/h and also the top speed achieved. To make analysis easier, the sprints have been grouped into short (1-2s in duration), medium (3-4s in duration) and long (5s+). What is most interesting about this statistic is how much variation exists between players and positions. Like total high intensity distance, the total number of sprints performed is a key BlackSticks index of work rate.

Part 3 - Example of Outputs and Interpretation

Following a match, players who have worn a GPS unit are provided with feedback concerning work rate, sprints performed and positional movements. To assess work rate the variables of distance covered and high intensity distance covered are analysed.

Table 3: Game Analysis - Distance Covered

Speed Zone	1 st Half		2 nd Half		Combined Total	
	Metres	% of distance	Metres	% of distance	Metres	% of distance
1	136	2.8	132	3.1	268	3.0
2	1106	21.1	1176	27.7	2282	25.4
3	1640	36.6	1678	39.5	3318	37.0
4	938	19.6	748	17.6	1686	18.8
5	586	14.4	344	8.1	930	10.4
6	312	6.5	172	4.0	484	5.4
Sum	4718		4250		8968	

Table 4: Distance Decrement between Halves

	Total Distance	HI Distance
1 st Half	4718	898
2 nd Half	4250	516
Decrement	9.9%	42.5%

Figure 2: Zonal Distance in Hockey Match



From tables 3 and 4 and figure 3 we can see that the athlete covered approximately 9km during the match. We also see that there was a decrement in distance covered of 9.9% between the 1st and 2nd halves (this is relatively typical). However, what is most striking about this data is the decrement in high intensity distance between halves, a massive 42.5%. Figure 2 illustrates that although a relatively similar amount of distance was covered the nature of that distance changed significantly with zones 2 and 3 (walking and jogging) increasing and zones 4-6 decreasing.

To further assess the work rate of a player it is possible to view the 'flow' of work throughout the

game. Figure 3 illustrates the distance covered by the player every minute of the match. Using the shape of the lines an opinion can be formed as to whether the player was consistently involved in the play (bars of relatively even height) or if he drifted in and out of the match (lots of peaks and troughs). With 60 seconds being such a short time interval there are a number of factors that can influence the shape of this curve i.e. an injury break, a sequence of penalty corners etc but nevertheless the graph shown can add weight to a coaches observation as to a players work rate and activity.

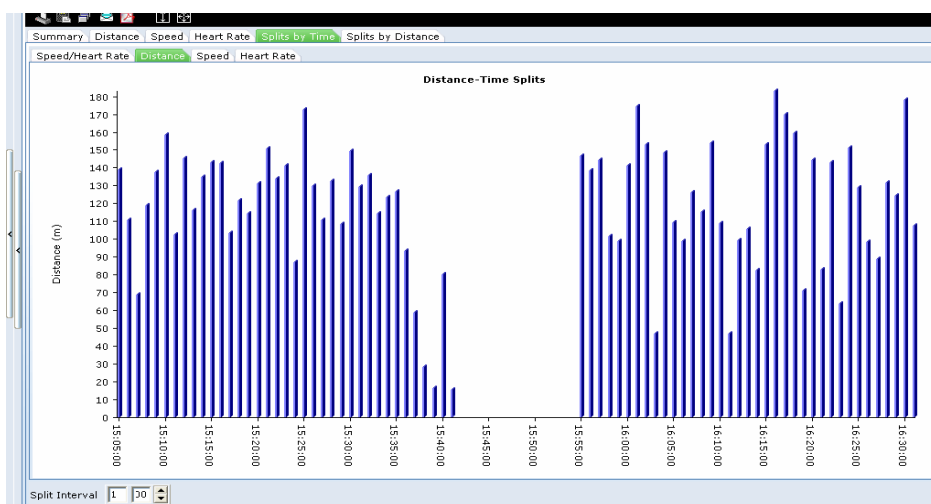


Figure 3: Distance Covered per Minute

An additional measure to assess consistency of work rate is to look at the number and spread of sprints performed. Figure 4 illustrates sprints performed by a player during a match. Each of the black vertical lines represents a sprint and the number in the box above it indicates the duration (in seconds) of the sprint. For this player the

sprints in the 1st half are more frequent than in the 2nd half (20 vs 14) and are also more tightly packed. As before, there are some assumptions to be made about the state of the game, score line etc but the observation can be made that work rate decreased in the second half.

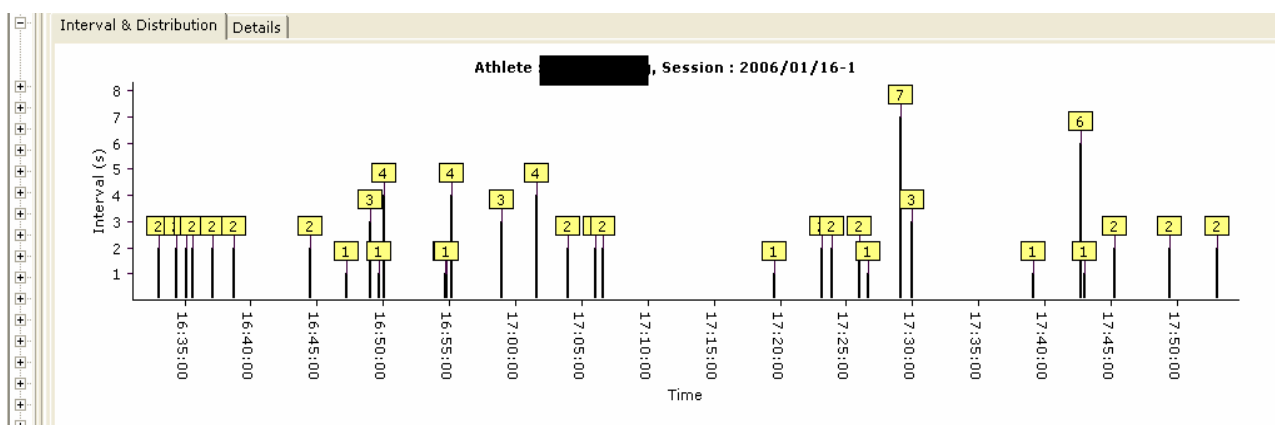


Figure 4: Sprints performed



Figure 5: Position during the first half

Figure 6: Location of high intensity running

Some final observations can be made by looking at the players movements on the pitch (please refer to figures 5 and 6). These figures show (for one half of the match) where the player was positioned and where the high intensity running was performed. From a coaching perspective, this information can be useful to identify errors in positional play and trends in match-play.



Part 4: Discussion and Application of Information

It is both interesting and enlightening to assess the physical performance of hockey players during matches. However, it is mostly the technical ability of a player/team that causes a positive match result and we do not want to emphasise physical attributes to the extent that we produce great athletes who are only average hockey players. Despite this, studies performed on professional soccer have found that teams finishing in the top half of the competition have consistently higher physical outputs than teams that finish in the bottom half of the competition so it is clear that there is an important relationship between technical and physical outputs and it is possible for teams to have high levels of both. Therefore we will continue to emphasise a high level of fitness from NZ players.

The collective GPS findings have been applied to many aspects of the Men’s BlackSticks programme including fitness training and assessment methods, use of substitutes during

matches and methods of match performance analysis.

Intermittent work capacity

The GPS data shows that once players have adequate aerobic fitness it is very important to place a high emphasis on intermittent work capacity (the ability to repeat short bursts of high intensity work with only short rests). Traditional hockey training exercises such as small sided games provide an excellent intermittent fitness stimulus and where necessary, supplementary intermittent training can also be added to team sessions. The blacksticks men use short (10-15 minutes) high intensity fitness sessions at most hockey practices (examples are shown below - please refer to table 5). These sessions consist of clusters or sets of repeated efforts. Efforts vary between 10-60 seconds and have rests of approximately 100% (i.e. if the work effort was 30 seconds long then the rest is also 30 seconds long). Long rests are given between clusters to allow for the high intensity to be maintained and active recovery (jogging) during these long rests is beneficial.

Table 5: On turf Intermittent Fitness Sessions

Session 1 - Short	Session 2 - Medium	Session 3 – Long + Short
Run 3 reps of a 5m/10m/15m shuttle with 15 seconds between reps Perform a total of 3 sets with 90 seconds between sets*	Run from the baseline to the 25 and back twice, rest 30 seconds and repeat Perform a total of 3 sets with 90 seconds between sets*	Run a full lap of the pitch at a high intensity (~60s), rest 20s and then run 2 reps of a 5m/10m/15m shuttle with 15 seconds between reps Repeat twice more for a total of 3 sets with 90 seconds between sets*

* It is very beneficial to spend the 90 second recovery period between sets doing something active e.g. jogging. A good option is to have the athletes perform a slow half lap of the pitch. This active recovery speeds the clearance of lactic acid from the blood.

Speed

Speed is considered by many to be a very significant component of elite performance and successful teams are often perceived to be faster than less successful teams. Approximately 3000 sprints were performed by players wearing GPS units in this study. Nearly two-thirds of these sprints (65%) were less than 10m long and despite performing some relatively long sprints (i.e. 40m+) very few players reached even 90% of their maximum speed as recorded during speed testing. These statistics suggest that prioritising the training of agility (change of direction) and quickness (acceleration over short distances) as compared to improving top speed is justified. It should be noted however that although rare in appearance, long sprints can often have significant impact on the match in both attacking and defensive situations so fast players are definitely a valuable asset to a team. In response to these findings the BlackSticks assess running speed on turf over distances of 50m and use an agility test. Speed training is performed at the start of selected team sessions and the exercises used predominantly focus on acceleration and agility. Most of these exercises are competitive races to maximise intensity.



Use of substitutes

Although analysis is still in progress, preliminary data suggests that the timing and organisation of substitutes can significantly affect overall physical outputs of a team during a game. Regularly

rotating strikers, inside forwards and the centre half will allow for maintenance of high intensity work throughout the game, particularly towards the end of each half. Overall work-rate is increased by approximately 5% with rotating substitutes.

The next steps

The data already collected provides a thorough understanding of the physical demands of elite men's hockey in New Zealand. The use of GPS tracking will continue in the programme with a variety of issues being of interest. One such issue is the effect of player combinations on overall physical outputs e.g. does player A in the centre half position work significantly harder when players B and C are inside forwards vs when players D and E are inside forwards. Another issue is the interaction with opponents i.e. does the right half have to work harder when marking striker A vs when marking striker B.

Summary

An elite men's hockey player covers approximately 8km per game with 1000-1400m of this distance being at high intensity. Depending on position, he performs 15-40 sprints per game with the majority of these being less than 10m in length. The ability to sustain a high work-rate throughout the game is a key physical performance indicator and can be easily assessed with the use of GPS tracking devices. The information gained through recent use of these devices is providing significant insight into the physical demands of the different positions. This is subsequently being used to guide specific fitness programming and also to help identify and assess potential avenues for performance enhancement such as substitution systems, defensive structures and formation options. Further advances in performance analysis through the integration of physical monitoring with technical monitoring (e.g. SportsCode team and player statistics) will provide the coaching team with an even stronger base of knowledge and information from which to base the 2008 Olympic campaign.

Acknowledgements:

- SPARC – generous support and funding for the project
- Kevin Towns – incorporation of the project and findings into the programme and providing ongoing advice, ideas and support
- Men's Blacksticks Players – tolerance towards the devices and enthusiasm for the information
- Hamish Baron - photographs