Evaluation of the use of a GPS data-logging device in a snowsport environment

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Abstract

This research explores the usability of a GPS data-logging device designed for team-based sports as a mechanism for collecting data on snowsport participants’ temporal and spatial use of alpine resorts. Usability for participants was high, however there are a few issues for the research that were challenging, but the quality and quantity of data obtained outweighs any limitations identified. Thus the researchers believe that GPS Spi Elite is a useful resource for tracking snowsport participants’ temporal and spatial use of alpine resorts.

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1. Introduction

Snowsport participation research has typically focused upon areas such as motivations [1], barriers to participation [2], market segmentation [3, 4], with some limited research measuring speeds within specified resort areas [5, 6]. There is no research that explores where snowsport participants move within resort areas, for how long they ski or board, nor how far and fast they travel throughout the day. While this information may be of use to resort and destination management, to actually track a tourist’s spatial behaviour can be time consuming, labour intensive and costly [7].

This project builds upon previous snowsport leisure and tourism research by investigating the application of GPS-based technologies that have been developed for use in team-based sports to explore the spatial movements of snowsport participants in a resort area. The information from this research will

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be of interest to resort managers for resort infrastructure development and planning; injury prevention strategy development based on usage patterns (e.g. speed and distance) and high-speed areas within resorts, and the workloads and potential for fatigue of a range of snowsport participants. The information will be of interest to resort developers in terms of the design of slopes, including zones of access, egress and congestion, and in the design and management of the tourist experience. It is also relevant to sports technology developers exploring new technologies for application across diverse sporting activities.

The research investigates the usability and ease of adaptation of the GPSports SPI Elite device, and the associated hardware and software, to provide a user-friendly output of a resort visitors’ snowsport participation. Usability in this context draws upon ISO 9241 which defines usability as ‘The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction’ [8].

For this research there were two groups of users: the researchers and the participants. From the perspective of the researchers they wanted to be able to easily set-up participants and to not have the participants’ daily activity inhibited nor compromised by their use of the device. From the perspective of the participant, it was expected that the output generated by the software would enhance their satisfaction by providing meaningful information on their movements around the resort, the distances they travelled, their level of exertion based on average and maximum heart rates, and maximum speeds obtained. For the researchers, efficiency related to the ease of set-up of participants, uploading of data to the software, and then analysis. Effectiveness refers to data collection, while satisfaction focuses upon whether the researchers’ expectations were achieved, such as whether sufficient quality data was obtained.

Between these two user groups there is a degree of interaction, such as the impact of the participants’ experience of the research upon the researchers; for example, the participants’ interest in the project and the data collected and their follow-up questions for further analysis of the data. If the participants were satisfied, this may also influence the satisfaction of the researcher. There is also the impact of the researcher and the research upon the participant. It was imperative, for instance, that the data collection process and the morning and afternoon meetings with researchers not negatively impact the snowsport experience of the participant.

2. Method

The GPS Sports SPI Elite (Figure 1) is a data-logging device worn in a mini backpack positioned in the upper thoracic region of the participant. It captures: time, distance, speed, heart rate, location, body load and impacts. The 76g unit records GPS position at up to 3 Hz and accelerations at 100 Hz onto a 128Mb memory card. For this project, GPS data was logged at a lower rate of 1.5 Hz to assist in conserving battery life. A non-replaceable li-ion rechargeable battery with up to 8 hours logging time powers the unit. The more data points, the more accurate the position. Heart rates are recorded to the SPI Elite using a wireless Polar T34 heart rate chest strap pickup.

The GPSport products were initially developed to enable elite sports teams to objectively evaluate the performances of their players in both training and competition settings (http://gpsports.com). These products are used internationally in team sports such as rugby union, rugby league, football and Australian Rules Football. There has been little application of this technology beyond team-based sports, however our research team has been investigating its application in diverse physical activity and environmental contexts since purchasing the units in 2007 [9, 10].

There are other personal location information products available, such as the Garmin Forerunner range, Flaik GPS and Recon-Zeal Transcend Heads Up Display Snow Goggles which are often targeted for personal use and are more user-friendly, however they have lower resolutions, or lack the robustness of the GPSports SPI Elite. For example the Garmin Forerunner 305 updates at 1Hz with an accuracy of
< 10metres compared to the 1.5 or 3 Hz of the SPI Elite with an accuracy of < 4metres [11].

The GPSs (Figure 1(a)) are placed in a docking station (Figure 1(b)) for downloading data and recharging the units. Data is analysed via the Team AMS software and may also be overlaid onto Google Earth for additional analysis and communication with participants (Figure 1(c)).

For this project a convenience sample of snowsport participants, predominantly using a snowball sampling method, was recruited in a western Canadian resort during the 2010/11 season and invited to wear the equipment. Participants also volunteered for the project either as a result of seeing an article in the resort newspaper or as a result of knowing others who had participated. The Human Ethics Committees of both the University of Canberra and Thompson Rivers University approved the project protocol. All participants provided informed consent prior to participation. One-hundred and twenty-four ‘skier days’ of data was collected, of which 104 skiers or snowboarders logged at least 4.5 km of travel, or one cycle of a lift. Further data was collected via a questionnaire to explore participants’ previous snowsport experience, and perception of the distance travelled and maximum speeds reached.

3. Results

Of the 104 ‘skier days’ analysed, the age range was 9 to 80 with a mean of 41.8 years, of which 39% were females. Most were skiers (93%), 30% of whom indicated they were novice or intermediate skill level and 70% who indicated they were advanced to expert. Table 1 provides summary details of the distance travelled, hours logged and maximum speeds for participants who travelled greater than 4.5km over their session. The average distance travelled per hour, including lifts, was 8.9 km.
Table 1. Time logged, distance travelled and maximum speeds of skiers and snowboarders where distance travelled is > 5km.

|                          | N  | Min | Max  | Sum    | Mean | Std. Dev |
|--------------------------|----|-----|------|--------|------|----------|
| GPS: hours logged (hr:mins) | 104| 00:17 | 07:38 | 503:10 | 04:50 | 01:52    |
| GPS: distance travelled (km) | 104| 4.7  | 120.7| 4,492.0| 43.19 | 20.00    |
| GPS: maximum speed (km/h)  | 104| 19.6 | 108.5| N/A    | 62.03 | 13.75    |

The data collected and the feedback from the participants, before they received information from the SPI Elite detailing their day’s snowsports activity, indicated that most do not know how fast they actually travel, nor how far they travel. From an injury prevention perspective, this lack of understanding may translate into inappropriate preparation for and management of their mountain experience to prevent fatigue and the likelihood of injury. Future analysis will explore the correlations between predicted maximum speeds, distance travelled and actual speeds and distances.

4. Discussion

Following are the usability advantages and disadvantages of applying the GPS SPI Elite in a non-traditional context as identified in this project.

4.1. Advantages

The GPSs produced high quality data across the parameters of time, distance, speed, heart rate, location, body load and impacts. The devices were appropriately robust for the task of recording data while participants performed snowsport activities. The devices were also small enough in size and weight to cause minimal or no reported interference with the wearer’s upper body movements nor impact their centre of balance. The lack of external displays such as with the Garmin Forerunner 305 or the Recon-Zeal Goggles proved an advantage, as there was no incentive for participants to vary their speed or increase their risk-taking behaviours, based upon any real-time feedback. The proprietary software supplied with the SPI Elite unit allowed easy transfer of data to other common software systems for additional analysis.

The value of this research is the ability to allow resort managers to identify actual speeds within specific areas of resorts, such as areas designated as ‘slow zones’. As well, a thorough understanding of usage patterns across the resort may assist resort managers with trail management, signage and the development of safety strategies for areas of high use and where high speed trails merge with areas used by less experienced participants. This usage data may also be compared with injury data to investigate whether there is a correlation between areas with more frequent incidents and areas where higher speeds are recorded, where a diversity of speeds are recorded, and where higher usage is evident.

4.2. Disadvantages

The original design of the GPS was for team sports in Australia. The norm for these would be a maximum duration of two hours with ambient temperatures well above zero degrees Celsius. In the context of snowsports, the units were being extended into another application in daylong activities in sub-zero temperatures. Consequently the battery life was potentially compromised by the extreme temperatures in the alpine environment, at times down to -20°C, which may have brought the temperatures in the proximity of the device when worn under their outer layer of clothing to around zero degrees.
Secondly, there was no means of replacing the battery during the period of use by the participant. A design aspect that would have been of use in this application would have been the presence of a battery status indicator on individual units that would provide status feedback to the researchers about the potential remaining battery life. An ability to adjust the GPS frequency of recording in-situ would add functionality to the units. This was noted by the research team as participants who were interested in their own performance while undertaking specific activities, such as ski race training, would like to have additional detail in the information about their performance (i.e. more data points recorded) on some sections of the mountain and not others. This could be achieved by being able to switch up the recording frequency when needed and switching down when not needed in order to save battery life. It is difficult to adjust the Hz setting and therefore the frequency of data points being logged. To adjust between 1.5 Hz and 3 Hz requires the uploading of software onto each individual GPS unit. There is a trade-off between logging more data points at the expense of battery life.

4.3. Research design limitations

A criticism of this type of research design is that the sample size of 104 is small compared to the numbers of daily participants in a resort and therefore, may not necessarily be representative of the broader population of snowsports participants. However, as with most research, it is a balance between cost of data collection in terms of time and expense of the GPSs (approximately AUD2,000 per unit) compared to the depth of data that may be obtained via units such as the GPS Spi Elite. The process of setting up individuals and small groups of participants may not be the most time effective means of data collection given the time required for recruitment, set-up and retrieval of equipment for often small sample sizes each day, however the depth of data collected minimises this limitation.

A further limitation in this type of research is the sampling method. A convenience sample incorporating a snowball sampling method meant that communication between avid skiers led to a higher percentage of advanced to expert skiers expressing an interest in participating in the study than may exist in the broader snowsport population.

4.4. Future research directions

In the future, other alpine resort activities may be explored to investigate comparative spatial movements, speeds and distances travelled such as lift-accessed mountain biking that may use similar terrain as skiing and snowboarding. The type of data obtained with devices such as the GPSport SPI Elite would aid in resort design as well as informing appropriate safety messages and design in areas such as protective equipment usage, trail selection and fatigue management. Further development of radio-frequency identification (RFIDs), and live-timing providing feedback in real time may provide further insights for resort managers into usage-levels and how the resort is being used under different snow and weather conditions. With technological improvements, newer similar GPS technologies have update rates of 15 Hz, but the increased accuracy decreases the battery life.

5. Conclusion

The depth of information collected suggests this is an effective method of collecting data about snowsport participants’ spatial movements within alpine resorts though there are some usability issues with the equipment as applied in this research design. With the growth of adventure sport pursuits involving half or all day participation, for example mountain biking, this robust technology allows the
possibility of accessing data about aspects of activity performance across extended periods of time. The current project confirms that the SPI Elite system provides information about spatial and physiological performance parameters that will be of interest for event planners, equipment manufacturers and sport safety coordinators across a range of potential sports.

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