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Performance Assessment Innovations for Elite Snowboarding

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Abstract

This paper provides a review of objective performance assessment in elite half-pipe snowboarding. Half-pipe snowboarding is currently coached and judged in competition using subjective measures. Like other sports that rely on subjectivity however, the methodology underpinning how coaches assess athletic progression and judges score performance is open for debate. This paper focuses on technology assisted, objective performance assessment. Key considerations are the specificity of the information, the accuracy and reliability of results, the processing time required and the current accessibility.

Keywords: Snowboarding; Halfpipe; Technology; Objectivity; Performance; Judging;

1. Snowboarding And Subjectivity

Once considered the pastime of social misfits and subversive nomads reneging on adult responsibilities, snowboarding has fast become a premier elite sporting discipline [1,2,3]. Regardless of its underlying antiauthoritarian and counterculture ideology, snowboarding is a sporting discipline the Olympic movement has been keen to embrace in its attempt to retain a continually shifting youth market [2,3]. The sport of snowboarding seems currently juxtaposed between its traditional ideals of freedom, hedonism and rebellion and the athletic ideals of discipline, control, and continual performance enhancement [1,2,4]. This paper is focused purely on objective methods to improve athletic performance and judging reliability. It has however been undertaken with consideration of the sport's traditional ideologies and emphasis of the "practice community" on the more stylistic aspects of performance. The current reliance on subjective performance assessment in half-pipe training and athlete preparation fails to utilize the benefits of objective information. In competition, the reliance on subjectivity is an open door for potential bias and judging corruption [4]. For coaches, athletes and judges who are involved in elite snowboarding competition, objective performance assessment is something that is yet to be utilized to its full potential. This paper therefore discusses a number of performance assessment methods that focus on objectivity

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specific to snowboard performance. Whilst video based analysis has the capacity to provide objective performance information [4,5,6], wearable and other technologies hold the key to unlocking novel performance assessment concepts within snowboarding. This paper is a review of technologically based methods of objective performance assessment focusing on their specificity, accuracy, reliability and current accessibility.

Half-pipe snowboarding consists of an athlete performing a series of aerial acrobatic maneuvers on a special course made of snow. Although dimensions vary, elite competition half-pipes are commonly 160 – 200m long, 18m wide, possess an inclination of approximately 18 degrees and have wall transitions of 7 - 8m [7]. The sport is focused on providing a platform allowing individuality and athletic freedom of expression and the routines performed by competitors are currently judged in competition by a subjective measure termed overall impression (OI). OI takes into account a number of sport specific components such as amplitude, degree of rotation, difficulty, style and execution, the sequence and combination of maneuvers, the use of the half-pipe including the line taken and how a run progresses and flows [7,8]. There is "practice community" awareness that a subjective focus can potentially identify incorrect results. However there is also a strong and somewhat paradoxical perception that this method of assessment is a major strength [9,10].

2. Competition And Objectivity

Objective analysis of snowboarding has attracted considerable interest from the research community [11 - 19] but only a few have focused on performance in half-pipe snowboarding [6, 17 - 19]. Notational analysis focused on objective variables with direct correlation to half-pipe competition performance has previously been undertaken with promising results [4,6]. There is strong community perception that air-time (AT) and degree of rotation (DR) play a major role in half-pipe competition success [9,10]. The combinations of these variables and the amount of shared variance they explain in competition scores however can only ever be determined objectively. Video analysis is widely used in snowboarding as a form of performance analysis, though it is primarily focused on subjective enhancement of style and trick execution. Video based analysis however can also be used to objectively assess performance variables specific to the sport.

In studies that have calculated objective information on AT and DR in half-pipe snowboarding, panning video footage was captured from the bottom of the half-pipe and was uploaded and digitized by video analysis software. AT data was analyzed using a digital stopwatch (resolution = 0.02s) whilst DR data was determined using "practice community" rules for aerial acrobatic maneuver classification. AT is measured in seconds and reflects the amount of time an athlete spends in the air during an aerial acrobatic maneuver. DR is measured in degrees and reflects the amount of rotations an athlete completes during the period of AT. It was originally thought the combinations and variance in competition scores explained by AT and DR differed from competition to competition based on athletic performance level, conditions and course dimensions. Whilst still believed to be partly true the importance of the performance variables of average air time (AAT) and average degree of rotation (ADR) are now well established. Briefly, AAT and ADR are always strongly and positively correlated with competitive success, explaining 66 - 94% of the shared variance in athletes subjectively judged scores [4,6]. This paper is therefore concerned with the best available methods with which to incorporate objective performance assessment into half-pipe snowboarding and to review the accuracy, reliability, specificity, speed and accessibility of those methods.

3. Technology And Performance Assessment

Well-timed, accurate and reliable feedback is a key contributing factor to improving athletic performance and it is believed such feedback would also be a key contributing factor in improving judging reliability [20,4]. Athletic performance assessment is now routinely focused on shifting out of the laboratory and into the field [5] and the advancements in microelectronics and other technologies mean it is now possible to build instrumentation small and unobtrusive enough for a number of field-based applications [21]. As laboratory based performance assessment of snowboarding is impossible, the sport is well placed to take advantage of this new shift in sport science ideology. It is important to note however that the objective data generated by wearable and other technologies must possess high validity and reliability and must allow unhindered performance to be useful in elite sporting contexts [22]. Fortunately the capacity of inertial sensors to accurately measure human motion thousands of times per second in multiple axes and at multiple points on the body is well established and on-board data storage negates the need for equipment tethering [23]. The aim of this area of monitoring however should not be to instrument everything on the body or equipment but rather to understand what information is required and to use appropriate sensors to provide such information [21]. There have been many attempts to develop or use technology to objectively quantify snowboarding in the field but few have focussed on generating data directly associated with elite performance. Whilst many use similar micro-electronics, those at the forefront seem to focus on competitive performance related data, are commercially based, and possess close ties to elite sport.

4. Emerging Technologies For Snowboarding

The six most established emerging technologies focused on providing objective data in snowboarding are shown in Table 1. Three of those, Shadowbox™, Hangtimer™, and AIS/Catapult Innovations [24,25,26,27] are wearable technologies using inertial sensors such as tri-axial accelerometers, rate gyroscopes, magnetometers and Global Positioning System (GPS) data as the primary technology whilst the other three, Video Analysis, EIM Solutions, Swatch/ST-Innovation [28,29,30] are image based technologies not worn or attached to the athlete in any way.

4.1. Image Based Technologies

As an image based system, video analysis is considered the criterion method for calculating objective data on AT [4,6]. Video however is associated with a large time delay in information feedback, relegating its use to providing subjective analysis of style and execution. The two image-based systems developed by EIM-Solutions and Swatch/ST-Innovation are very similar to each other, both using manual post processing of Light-Emitting Diode (LED) photographic images (1000Hz) over a calibrated, software generated grid to generate objective jump height (JH) data achieved during snowboarding. At the forefront of integration into competition, EIM Solutions and Swatch/ST-Innovation are the current objective data providers for the Ticket To Ride (TTR) World Snowboard Tour and O'Neil Evolution snowboard events, respectively. The level of integration into elite competition is currently unmatched by the other systems shown in Table 1. TTR snowboard competition in particular, is elite and influential. Athlete rankings achieved on the TTR arguably garners more respect in snowboard communities than those achieved on the Fédération Internationale de Ski (FIS) sanctioned World Cup and Winter Olympic competitions [1,2,3]. These two image based systems possess the following advantages over others shown in Table 1: 1. They do not require the athlete to wear equipment. 2. They have extremely fast processing times, providing JH data approximately two seconds after an athlete finishes a run. 3. They are accurate and reliable (± 10.00 and ± 5.00cm for Swatch/ST-Innovation and EIM Solutions respectively) 4. They measure JH instead of AT. AT can in some instances be a flawed measure (for example when an athlete lands in the flats of the half-pipe) however AAT and ADR are still strongly correlated to competition performance [4,6]. 5. They are extremely well integrated into elite competition. The disadvantages with these systems include: 1. Long set up duration. 2. They require two people to run and maintain. 3. Jump height achieved during snowboarding aerial acrobatics is currently the only data provided. 3. They are not commercially available removing the ability of coaches and athletes to use these systems in routine training environments.

4.2. Wearable Technologies

The other three systems shown in Table 1 utilize various combinations of inertial sensors and signal processing to generate objective data specific to snowboarding. They are considered wearable technologies. Shadowbox™ utilize a filtered analysis of 100Hz tri-axial accelerometer, tri-axial rate gyroscope, tri-axial magnetometer and GPS data providing a three dimensional trajectory from which their objective information is derived. The AIS/Catapult Innovations system has used various signal processing techniques with tri-axial accelerometer data to calculate AT and signal processing involving integration by summation of tri-axial rate gyroscope data to calculate DR and classify aerial acrobatics [4]. The Hangtimer™ system utilizes 100Hz tri-axial accelerometers and an unpublished signal processing technique to calculate information on AT only. All three wearable technologies shown in Table 1 have been integrated into competition but not at the same level or to the same extent as the image based systems from EIM Solutions and Swatch/ST-Innovation. Like these image based technologies, two of the wearable technologies (Shadowbox™ and Hangtimer™) do not provide transparent or published validity information and, considering the variety of sports they calculate data for, would be of concern to sports scientists wishing to use them in a performance analysis context. The half-pipe snowboarding specific AIS/Catapult Innovations system offers published validation information but it is currently unavailable outside the Australian sports system. A disadvantage of all wearable technology is the necessity for attachment to athletes or equipment, something not required by the image based systems. Many athletes would refuse to be instrumented in such a way for competition, especially in high risk sports such as snowboarding [9,10]. Sophisticated packaging [31] allowing sensors to be embedded into competition bibs could solve this issue [32]. The advantages wearable technologies (apart from Hangtimer™) have over the image based systems is the range of data they can provide. The Shadowbox™ system is the most comprehensive, calculating data on AT, DR, JH, and spin rate (SR) whilst the AIS/Catapult Innovations system provides AT calculation and DR classification. Additionally, these wearable technologies are readily available for coaches and athletes to use in routine training, something currently impossible with the two image based systems. Until relatively recently, scientists, coaches and athletes wishing to integrate some form of objectivity into half-pipe snowboarding training would be restricted to the use of video analysis. This paper has shown that the ability of micro and other technologies to provide this data is now well established and for the most part readily available.

Table 1. Emerging technologies focused on providing sport specific objective data in elite-level snowboarding. Analysis by literature review and correspondence. Review based on the objective KPV data for one athlete.

System	Method	KPV	Error	Published Validation	Process Time	Size(mm) Weight(g)	Labour	Integration	Availability	Cons
EIM Solutions	M1	JH	5.00cm	No	2.00s	NA	2	Yes I1 2009	No Contracted	Unpublished Contracted
Swatch/ ST Innovation	M2	JH	10.00cm	No	2.00s	NA	2	Yes I2 2008	No Contracted	Unpublished Contracted
AIS/Catapult Innovations	M3	AT DR	0.03s 0.00°	Yes [4]	≠150.00s [4]	82x46x20 60.00g	1	Yes I3 2007	*Yes Commercial	Process Time Prototype
Shadowbox™	M4	AT DR JH SR	0.10s NA NA NA	No	5.00s	91x59x19 120.00g	1	Yes I4 2009	Yes Commercial	Unpublished
Hangtimer™	M5	AT	NA	No	5.00s	76x64x18 70.00g	1	Yes I5 2009	Yes Commercial	Unpublished Only AT
Video Analysis	M6	AT DR SA	0.01s 0.00° NA	Yes [6]	360.00s [4,6]	NA	1	Yes I6 2007	Yes Commercial	Process Time

SYSTEM, Company / Device name; **METHODS**, M1, Manual post processing of Light-Emitting Diode (LED) photographic images captured at 1000Hz; M2, Manual post processing of Light-Emitting Diode (LED) photographic images captured at 1000Hz; M3, Signal processing (FFT and threshold based analysis) of tri-axial accelerometer data outputs for air-time and signal processing (integration by summation of tri-axial rate gyroscope data outputs) for degree of rotation and trick classification [4]; M4, Filtered analysis of tri-axial accelerometer, tri-axial rate gyroscope and tri-axial magnetometer data outputs providing a 3D trajectory; M5, Unknown and unpublished signal processing of 100Hz tri-axial accelerometer data; M6, Manual post processing of 50Hz video footage with video analysis software [28] using definitions and rules according to [4]; **KPV**, Key Performance Variable; AT, Air Time; DR, Degree of Rotation; SR, Spin Rate; JH, Jump Height; TC, Trick Classification; SA, Subjective Analysis; NA, information not available; **ERROR**, ± Absolute mean error; °, degrees; s, seconds; cm, centimetres; **PROCESSING TIME**, Time it takes from the completion of a half-pipe run to when you can view objective information; ≠, Assessed downloading and calculating data from 3 hours of half-pipe snowboarding [4]; **SIZE / WEIGHT**, Size and weight of system , size in length x breadth x depth (mm), weight in grams (g); **LABOUR**, How many people does it take to run and maintain the system; **INTEGRATION**, Has the event been integrated into snowboarding?; I1, Billabong Air & Style Snowboard Competition (6Star TTR Event), Innsbruck Austria, 31/01/2009; I2, O'Neil Evolution Snowboard Tour, Davos Switzerland, 05/012008; I3, AIS Micro-Tech Pipe Challenge, Perisher Valley Australia, 30/07/2007; I4, AWSI Kite-Boarding Big Air Demo, Oregon USA, 17/09/2009; I5, Junior Snowboard Big Air Competition, Steamboat Springs USA, 2009; I6, Routine training for Australian national half-pipe snowboard team, Perisher Valley Australia, 30/07/2007; **AVAILABILITY**, Commercial, Available through commercial means; Contracted, Only available as a contracted service by the provider; *, Commercially available however half-pipe specific software still a prototype system. **CONS**, Major disadvantages associated with each system of automated objectivity.

5. Discussion

The pursuit of ecologically valid data is now a priority in field based performance assessment, notwithstanding the difficulties presented in this approach [5,33]. A search on snowboarding technology reveals a plethora of patents focussed on detecting and calculating objective data associated with aerial acrobatics in skiing, snowboarding and other sports. Many of these projects and prototype systems however have either focussed on other snow sports such as skiing or ski jumping, other components of snowboarding (forces on body segments, boots and bindings, and associated injury rates) or have systems that can generate the data this paper is focussed upon but they are disadvantaged by bulky measurement systems and athlete tethering.

We believe the key considerations for a system of objectivity based on micro or other technologies to effectively provide specific performance data for the sport of half-pipe snowboarding include: 1. The specificity and relevance of the information to the sport itself. 2. The ability to provide data without hindrance to an athlete's performance. 3. The accuracy and reliability of the data provided. 4. The processing time required and 5. The accessibility of the method to the wider snowboarding community, including coaches, athletes, judges and team support staff. The most prevalent technologies that have adhered to these considerations have become the focus of this paper.

The emerging technologies shown in Table 1 reveal it is no longer a question of whether the innovation is there but rather if and how coaches, athletes and competition judges plan to integrate and utilise the information provided. With strong, positive correlations between sport specific objectivity and competition scores, it is intuitively appealing to propose a judging protocol that incorporates both objective and subjective data [4,6]. Defining who should determine the nature of a sport ought not be a difficult issue. It seems imperative to ensure those affected (the "practice community") are allowed to articulate their interests in forums that convey influence.

Using objectivity to form part of an athlete's competition score currently seems out of context with "practice community" aspirations. Athletes, coaches and judges are not totally opposed to the idea however there is a strong perception that further development and integration of these concepts be conducted in close association with core community members and be controlled from within the sport [9,10]. At present, all emerging technologies shown in Table 1, even the two image based systems at the forefront of integration have only used objective data as side events to the main competition and as part of ongoing trials into judging assistance.

The potential for coaches and athletes to utilise this information in routine training environments is however less complex. Accurate and reliable feedback is a key contributing factor to improving athletic performance and the objective identification of the performance indicators most highly correlated with success in snowboard competition provides a basis for developing and implementing individual athlete strategy, dependable assessment of performance progression, and team selection criteria. The uptake of the performance assessment innovations discussed in this paper is slowly emerging with the snowboarding community and most have a positive view on a collaborative introduction of technology and the associated objective information it can provide.

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