SPRINT KAYAKING STROKE RATE RELIABILITY, VARIABILITY AND VALIDITY OF THE DIGITRAINER ACCELEROMETER COMPARED TO GOPRO VIDEO MEASUREMENT

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Reliability, variability, and validity of stroke rate measured via a Digitrainer accelerometer and GoPro 60 Hz video camera were determined. Six elite New Zealand kayakers (three males, three females) performed three trials of 300-m sprints in a single kayak (K1) mounted with the Digitrainer and camera. Average individual within-trial reliability and between-trial reliability and variability were calculated using data from 40 strokes beginning at 200-m. Both Digitrainer and video showed good reliability (Mdiff% ≤5%; ES ≤0.6), and moderate variability (ICC <0.67; TE% <10%). There was good agreement between Digitrainer and video stroke rates (r=0.86, p=0.000), however the Digitrainer overestimated stroke rate by 4 ±5 spm. Both systems can assess relative change in stroke rate, however video should be used when valid stroke rates are required.

KEY WORDS: analysis, immediate feedback, technique, technology.

INTRODUCTION: To enhance the practical implications for applied service work, biomechanics research should aim toward determining methods suitable for identifying change in an individual paddler or small groups of paddlers (i.e. an elite squad training under the same coach) which may be possible by using stroke-to-stroke data. Mononen and Viitasalo (1995) identified stroke rate as the most important predictor of performance in sprint kayaking (r=0.86; p<0.001). Stroke rates can be mathematically derived from video or accelerometer data. Using videography requires post-event processing so does not allow direct feedback to the paddler during training. Alternatively, the Digitrainer GPS-accelerometer system (Polaritas GM Electronic Research, Design & Manufacturing Ltd. Budapest, HUN) offers stroke rate displayed on a screen for live feedback which may be useful for training programmes if reliable. Janssen and Sachlikidis (2010) reported that the minimaxX GPS-based accelerometer under-reported kayak velocity by 0.14-0.19 m/s and acceleration by 1.67 m/s^2 when compared to video-derived measurements of 12 trials performed at three stroke rates. Stroke rates of 60, 84, and 108 strokes per minute were prescribed using a metronome and confirmed during data analysis, but it was not clear whether stroke rate measures from the minimaxX were valid, or if the adherence to the metronome feedback was confirmed using video data. Reliability and variability of stroke rate over a period of strokes have not been reported in sprint kayaking, nor has the accuracy of accelerometer derived stroke rates been documented. Therefore, this study aimed to determine the reliability, variability and validity of stroke rate measured via a Digitrainer GPS-accelerometer system and a GoPro 60 Hz video camera with post-event processing using QuickTime 7 Pro.

METHODS: The methods were approved by the Auckland University of Technology Ethics Committee. Six New Zealand elite kayakers (three males and three females) aged 20-22 years volunteered for this study.

The Digitrainer recorded acceleration data in three axes at 125 Hz and boat location via GPS at 1 Hz throughout each trial. Data were stored in the internal memory, and TechniqueStudio software (Polaritas GM Electronic Research, Design & Manufacturing Ltd. Budapest, HUN) was used to review data. A GoPro digital video camera (GoPro, Half Moon Bay, USA) sampling at 60 Hz recorded blade entry points to calculate stroke rate.

The Digitrainer was mounted to the back of the K1 boat behind the paddler, so that the paddler was not influenced by the display screen. The video camera recorded the Digitrainer screen for an initial 10 s for synchronization, then was secured within a waterproof casing and mounted to the front of the K1 boat to record blade entry points, which were later used to calculate stroke rate (Figure 1 for equipment set-up). Paddlers were then asked to perform three 300-m sprints from a floating start at a self selected constant race pace.

Beginning at 200-m, 40 single-sided strokes were analyzed. A single-sided stroke was defined from the first point of blade-water contact (catch) of one side to the catch of the opposite side for the video data. Video was reviewed with QuickTime 7 Pro (Apple Inc., Cupertino, USA). Frame numbers for each catch were entered into Excel (Microsoft, Redmond, USA). Stroke rate data from the Digitrainer was exported from TechniqueStudio software to Excel for analysis. All variables were log transformed to stabilise variance. Stroke rates were represented in strokes per minute (spm) of a single-sided stroke.

Figure 1: An instrumented kayak with the Digitrainer (left) mounted on the flat surface of the kayak just behind the paddler, and camera (right) mounted in front of the paddler on the kayak bow.

A five-point moving average was applied to the 40 stroke data samples, which reduced the sample size to 36 stroke rate values for each trial for each individual. Average individual within-trial reliability was assessed using the averaged coefficient of variation (CV%) calculated for each individual within each of the three trials. The CV% was calculated from the standard deviation displayed as a percentage of the mean.

The stroke rate from the Digitrainer was derived from the accelerometer which sampled at 125 Hz and had the ability to detect stroke rate to the nearest single digit (≤1% at stroke rates over 100). The error of one frame of video equated to a difference of three strokes per minute at the average stroke rate of 106, so 2.8% was the criterion for good reliability for video-derived stroke rate. Given the larger 2.8% for video than the 1% for the Digitrainer, 2.8% was also used as the criterion of good reliability for the Digitrainer to enable comparison of the two systems. A coefficient of variation greater than the criterion for good reliability was considered poor.

Average individual between-trial reliability and variability were computed for each pair of trials (2-1 and 3-2) for each paddler separately using all strokes then individual results were averaged. Average individual between-trial reliability was determined by the percentage differences in the means (Mdiff%) and Cohen's effect sizes (ES). Good reliability was interpreted when the Mdiff% ≤5% and ES ≤0.6 (Bradshaw, Hume, Calton, & Aisbett, 2010). Moderate reliability was interpreted when only one criteria of good reliability was met (Mdiff%

>5% or ES >0.6), and poor reliability was interpreted when neither criteria of good reliability were met (Mdiff% >5% and ES >0.6) (Bradshaw et al., 2010).

Between-trial variability (average individual and grouped) was determined using typical error expressed as a percentage of the mean (TE%), and intra-class correlation coefficients (ICC). Small variability was determined when the ICC >0.67 and TE% ≤10%, moderate variability was determined when only one criteria of small variability was met (ICC <0.67 or TE% >10%), and large variability was determined when neither criteria of small variability were met (ICC <0.67 and TE% >10%) (Bradshaw et al., 2010).

All data were calculated using Microsoft Excel (Microsoft, Redmond, USA), and the level for confidence limits was set at 90%.

Pearson correlation coefficients (r) were calculated (statistical significance set at p=0.05) using SPSS (IBM, Armonk, USA) to determine validity of the Digitrainer system for stroke rate using video data as the gold standard. The difference between stroke rate from the Digitrainer and video was calculated for each stroke for each individual's trials. The mean and standard deviation of the stroke rate difference was used to determine if the Digitrainer was overestimating or underestimating stroke rate compared to the video.

RESULTS: Average individual descriptive statistics (means and standard deviations) and average individual within-trial variability (CV%) are summarised in Table 1. Average individual between-trial reliability (Mdiff%, ES) and average individual between-trial variability (TE%, ICC) for all trials for five-point moving average analysis of stroke rate are summarised in Table 2. Both Digitrainer and video showed good reliability (Mdiff% ≤5%; ES ≤0.6), and moderate variability (ICC <0.67; TE% <10%). A pearson correlation coefficient showed good agreement between the Digitrainer stroke rate and the video derived stroke rate (r=0.86, p=0.000) however the Digitrainer tended to overestimate stroke rate by 4 ±5 spm.

Table 1: Average individual within-trial descriptive statistics (mean ±SD) and reliability (CV%) of stroke rate using five-point moving average (n=36) analysis.

Variables	Trial 1		Trial 2		Trial 3	
	Mean ±SD	CV%	Mean ±SD	CV%	Mean ±SD	CV%
Stroke rate: Digitrainer (spm)	108 ±2.8	2.6	106 ±2.3	2.2	106 ±2.6	2.4
Stroke rate: Video (spm)	103 ±2.3	2.2	101 ±1.8	1.8	102 ±2.1	2.0

Table 2: Average individual between-trial reliability (Mdiff%, ES) and variability (ICCr, TE%), using averaged individual five-point moving average (n=36) analysis.

Variables	Mdiff (%)	ES	Average reliability	ICC	TE (%)	Average variability
			Trials 2-1			
Stroke rate: Digitrainer (spm)	-1.42	-0.50	Good	0.22	2.01	Moderate
Stroke rate: Video (spm)	-1.55	-0.58	Good	0.40	1.45	Moderate
			Trials 3-2			
Stroke rate: Digitrainer (spm)	0.24	0.06	Good	0.28	2.05	Moderate
Stroke rate: Video (spm)	0.81	0.24	Good	0.26	1.61	Moderate

DISCUSSION: This was the first study, to the authors' knowledge, in sprint kayaking to document the variation of stroke rate measures using individual stroke data using two different products for measuring stroke rate. There were three key findings of this study. First, the Digitrainer and video stroke rates were both reliable within- and between-trials when analysing individual data using a five-point moving average. Within-trial reliability was good when it was less than the error of measurement due to the precision of the equipment (1% for the Digitrainer and 2.8% for the video camera). Although both ways of measuring stroke rate were reliable, video seemed to be more reliable shown by the slightly lower coefficient of variations compared to the Digitrainer. Second, the Digitrainer and video stroke rates both had an acceptable (moderate) level of variability between trials. Although there

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seemed to be no difference in the variability between pairs of trials for both devices, we recommend using the first trial as a familiarisation trial, given reliability was better between trials 3-2. Third, the Digitrainer did not produce a valid stroke rate compared to the video data. Despite the strong relationship found between Digitrainer and video stroke rate, the mean difference for all strokes for each participant's trials was larger (4 ±5 spm) than the error of measurement due to the precision of the video camera (3 spm or 2.8%). The Digitrainer had a tendency to overestimate stroke rate, but the large standard deviation of the mean difference showed that it did not consistently overestimate stroke rate, nor overestimate stroke rate at the same value. Therefore an adjustment equation cannot be used. Given the good reliability, however, both systems are adequate for training and assessment feedback if used appropriately.

Providing immediate feedback on a console directly to the paddler is an advantage for the Digitrainer system. However the Digitrainer was more expensive than the video camera used in this study. An appropriate use for the Digitrainer would include using the immediate feedback for sub-elite paddlers to help with the consistency of the paddler's stroke rates or to make relative increases in stroke rate based on a self-selected stroke. The coach could also store data easily on a laptop and track improvements within a season, with little post-processing time.

Aside from the good reliability and greater accuracy, an additional benefit from the video is that each stroke can be divided into two or four phases offering a greater depth of analysis, but the disadvantage is that analyzing video for more than two to three strokes can be time-consuming. However, when accuracy is important, video should be used.

CONCLUSION: The Digitrainer and video stroke rates were reliable within- and between-trials, and their variability was moderate (acceptable) between trials. However, the Digitrainer was not valid for stroke rate measurement. Despite these findings, there were advantages and disadvantages for both systems, and we conclude that both devices can be used if used appropriately. Video should be used for research, when assessing elite paddlers' stroke rates, or anytime accuracy is important. When immediate feedback and quick post-event processing time outweighs the importance of a true stroke rate measure, then the Digitrainer is useful. It should be noted that the Digitrainer tended to overestimate stroke rate by 4 ±5 spm compared with boat mounted video sampled at 60 Hz, so only relative assessments should be made.

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