DISCRETE MEASURES OF C-1 CRAFT ACCELERATION USING VARIOUS PADDLE DESIGNS

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Technology has given the biomechanist tools required to develop more complicated models of performance. Recently, the Sport Science Laboratory at Dalhousie University has been conducting experiments using an in-board accelerometer to measure craft dynamics of a single scull when propelled by macon and hatchet rowing oars (Pelham et al., 1993A and 1993B; Peach et al.). This was a concept first discussed by Duchesnes (1987). It was believed the above mentioned'methodologies could be expanded for use with other similar sports, such as C-1 canoeing.

Slight increases in performance may result from a change in physiological condition, improved technique, better equipment, or a combination of these factors. Therefore, it is extremely important that an athlete in this sport chooses the equipment that will maximize performance over the entire race. In this study five different paddle designs were analyzed in order to detect differences in the C-1 boat dynamics when propelled by an Olympic athlete.

Each stroke started with the paddle being placed in the water which is called the catch. At this point the deceleration of the C-1 canoe was maximum (see figure 1, point A). The canoe continued to decelerate, from point A to B on figure 1. Once the paddle generated a force causing the canoe to positively accelerate (see figure 1, point B), the canoe continued to accelerate until release (see figure 1, point C). Athletes using paddles that efficiently generate positive acceleration and reduce deceleration will be able to reduce total race time.

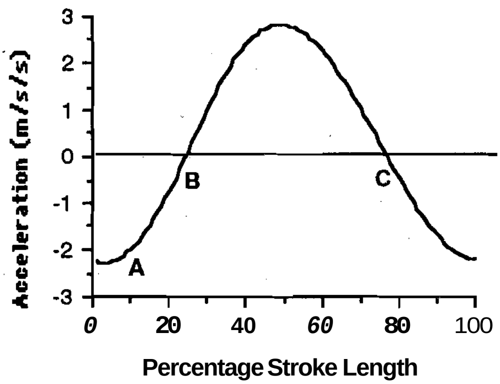


Figure 1. Craft Acceleration

METHODOLOGY

The subject, a male world class C-1 flat-water canoeing champion (height: 183 cm; mass: 78 Kg), was taped during the middle section of a 100 m segment while at top speed, using five different paddle designs on a fresh water lake. Video data was collected using an 8 mm Hitachi video camera, mounted on a tripod and placed on a dock which was approximately 20 m away, this permitted analysis of 1 to 2 strokes per trial. The video sampling rate was calculated to be 29.1±0.823 by using a drop test (Peach et al.). Acceleration data was collected using the g.analyst accelerometer

(Valentine Research Inc.), placed in the canoe near the centre of rotation. The accelerometer was statically calibrated to be accurate to ±0.008 g's (Peach et al.) and sampled at 10 Hz. A standard camera flash was used and connected to the start button on the accelerometer in order to synchronize the two sets of data.

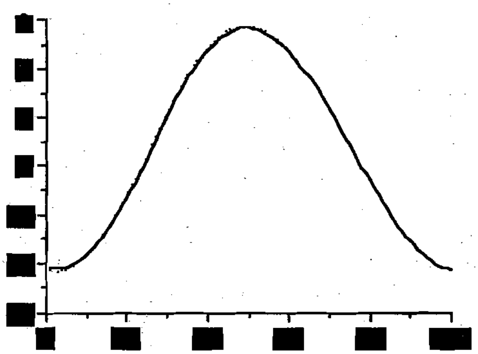
The acceleration data was standardized, using a software package written in ANSI standard C which ran on a Unix system, (Peach et al.). This procedure involved parsing the acceleration data into strokes and then using a cubic spline to standardize the stroke length (SL). The percentage stroke length (%SL) to the vertex of the concave down curve in the acceleration data which represents the time to peak acceleration (TPA) and the value at peak acceleration. (VPA) were also recorded. A series of one way ANOVAs were performed to compare the discrete measures between the different paddle designs.

The video data was encoded with a sequential number written on each frame. Then five strokes, from each paddle design, were used in conjunction with the video data to confirm that the location of the catch was correctly detected by the software. The Peak Performance 2D System was used to digitize the video at the beginning of the catch phase, end of the power phase and the end of the release phase.

All five paddles were the same length, with the same blade area except for the Big Blade which had a larger surface area. The C Fibre was composed of carbon fibre, the Big Blade was wood, the angle paddles were comprised of a wood shaft and carbon fibre blade. The angle was measured at the conjunction of the shaft and blade.

RESULTS AND DISCUSSION

Canoe acceleration data was used to examine differences among paddle designs. The craft acceleration for each stroke has a characteristic bell shaped curve which can be seen in Figure 2. These mean acceleration curves appear to be similar in quality. To statistically compare the standardized acceleration curves two discrete



measures were made: the time to peak acceleration, TPA, and the acceleration at this point, VPA. Table 1 shows the descriptive statistics of the TPA for the 5 paddle designs. The results of the ANOVAs showed that the variance between TPA for each paddle design was not significant.

Table 1. Descriptive Statistics of TPA

Paddle Type	Number of Strokes	Mean (%SL)	SD (%SL)	Minimum (%SL)
5 degree	27	48.074	2.986	43
3 degree	48	48.500	2.634	41
0 degree	33	48.394	2.738	43
Big Blade	13	46.923	2.465	43
C Fibre	14	48.571	2.533	43

The VPA was determined and Table 2 shows the descriptive statistics. The results of the ANOVAs showed that the variance between VPA for each paddle designs was not significant.

Table 2. Descriptive Statistics of VPA

Paddle Type	Number of Strokes	Mean (m/s/s)	SD (m/s/s)	Minimum (m/s/s)
5 degree	27	2.867	0.203	2.578
3 degree	48	2.871	0.234	2.333
0 degree	33	2.863	0.242	2.562
Big Blade	13	2.864	0.179	2.587
C Fibre	14	2.844	0.207	2.655

When the standardized acceleration curves where overlaid (Figure 2) the curves came very close to mapping over each other. This shows that the chosen subject's skill is both highly automated and adjustable. With the use of this accelerometry technique, investigators were able to detect very small differences in rowing performance (Peach et al.). It might be that the biomechanical differences among different paddles may never be of statistical significance, yet very small alterations may prove to have cumulative effects on the whole performance. Although not statistically significant in regards to the variables TPA and VPA, small differences were noticed for the 5 degree and other paddles. Nolte (1993) suggested that there is a difference in total rowing race times of less than 1% between the macon and hatchet oars. Therefore, if there are biomechanical performance differences between the selected paddles, it is most likely that they will reduce total race time by approximately 1%.

Acceleration measurements of the craft could prove to be invaluable to both coach and researchers. The proper integration of accelerometry to analyze boat dynamics with video to analyze movement patterns would give the athlete, coach and researcher more complete information as they attempt to optimize technique. In this way the canoeist is not limited to a predetermined set of motion patterns but can develop a technique that is "best" themselves. With the use of acceleration measures and through a series of experimentation and coaching. a personalized technique should evolve.

CONCLUSION

No significant difference between the 5 selected paddles could be determined.The biornechanical effects on the acceleration of the canoe by the selected paddles were small, perhaps nonexistent for that short period of time when data were collection. However, the energy requirements may have been different for each paddle and only a combined physiological and biomechanical analysis over an entire race might allow that observation to be made.

The use of acceleration measurements as a training and evaluation tool is easily automated and provides direct feedback to the coach about the effect of the canoeists efforts on the dynamics of the boat.

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