THE EFFECT OF OAR DESIGN ON SCULL BOAT DYNAMICS

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INTRODUCTION

Sport manufacturers have generally overlooked the usefulness of sport specific scientific experimentation in designing and evaluating their new equipment. A case in point is the new "hatchet" oar, currently used by an ever increasing number of rowers, who believe that this design (hatchet shape), with its shorter lever arm (hatchet, 290 cm versus macon, 298 cm) and increased blade size (area of hatchet, 21.5 cm^2 versus macon, 18 cm^2) will result in less blade slippage, thereby generating more force at the blade and greater propulsion of the boat compared to the traditional macon oar. The actual competitive or on-water data to support this notion is not available. Since it would be most helpful to athletes and coaches alike, the purpose of this paper was to identify and compare the boat dynamics of a single scull rowed by an elite rower using both macon and hatchet oars.

METHODOLOGY

The subject, an Olympian, is a 22 year old male sculler. The subject stands 196 cm, and has a body mass of 90 kgs, and is in exceptional physiological condition. Opinions of experts (coaches) and his past performances suggest that the skill level of the subject is high, and well automated.

To record horizontal linear acceleration of the scull, a triaxial g-Analyst (Valentine Research Inc.) was used. The g-Analyst is in fact, three electromagnetic force-balance accelerometers with flexure suspension in an orthogonal alignment. Measurement resolution was $\pm$ 0.10g ($g=9.8m/sec^2$). The data sampling rate was 10 samples per second with a memory capacity of 4800 samples. A 12V DC battery was required to power the system. Three Duracell LR44 batteries were used to maintain electronic memory.

The g-Analyst and battery were mounted on a stable, horizontal wood support fixed to the hull of the scull. The horizontal axis of the g-Analyst was parallel to the long axis of the boat. Calibration was done as described in the operating instructions manual. To correct for roll and pitch, roll rate was set at 8.5°/g and the pitch rate, 2.5°/g. Data magnification was 0.25 g. A 1990 Hudson heavyweight single scull was the craft of choice.

Video from the lateral perspective (in powerboat) permitted the analysis of the entire stroke cycle. The camera was mounted on a tripod providing stability. During on-water filming wave action was moderate to mild resulting in very little unnecessary boat motion. Markings were placed on the scull, and the subject wore a minimum amount of clothing. Images were clear. For test trials, a 200 m racing lane was constructed. The subject was allowed to build rhythm and stabilize technique prior to entering the 200 m trial and filming zone. The subject was required to row his normal race rate (32 strokes/min). The camera was approximately 6 m from the subject and in the aforementioned motor boat travelling parallel to the subject. In trial one, the subject used the hatchet oars. After a period of time for recovery, and adjustment, the subject used the macon oars for the second trial. The subject was instructed to row both trials with the same effort and stroke rate. A stroke rate monitor (strokecoach, Nielsen-Kellerman) was used by the subject to maintain the same stroke rate in both trials. Total times and stroke rates were recorded for both trials.

The curves to be analyzed, one stroke with each oar, or a series of strokes with each oar were selected by an expert coach. In the opinion of the coach, after viewing the film, these strokes most closely represented typical strokes for the subject during a race. Acceleration data from the g-Analyst was transferred to a Macintosh Plus using the g-Logger I-MAC software package (Valentine Research Inc.). Further data analysis programs were designed to convert the acceleration data to velocity, distance and impulse.

RESULTS

All measured variables (peak horizontal linear acceleration, peak horizontal linear velocity, average horizontal linear acceleration, average horizontal linear velocity, duration of the horizontal linear acceleration phase, duration of the horizontal linear velocity phase and the positive horizontal linear impulse) were greater with the hatchet oars compared to the macon oars (Figures 1, 2, 3). Total time for hatchet trial was 20.58 s and 20.98 s for the macon trial. A typical positive impulse for a hatchet stroke was 219.48 N.s and 216.32 N.s for the macon stroke. Negative impulse values were -131.42 N.s and -137.29 N.s for the hatchet stroke and the macon respectively while the total impulse for a hatchet stroke was 88.06 N.s and for the macon stroke was 79.03 N.s. The drive phase with the hatchet oars was longer than that of the macon oars.

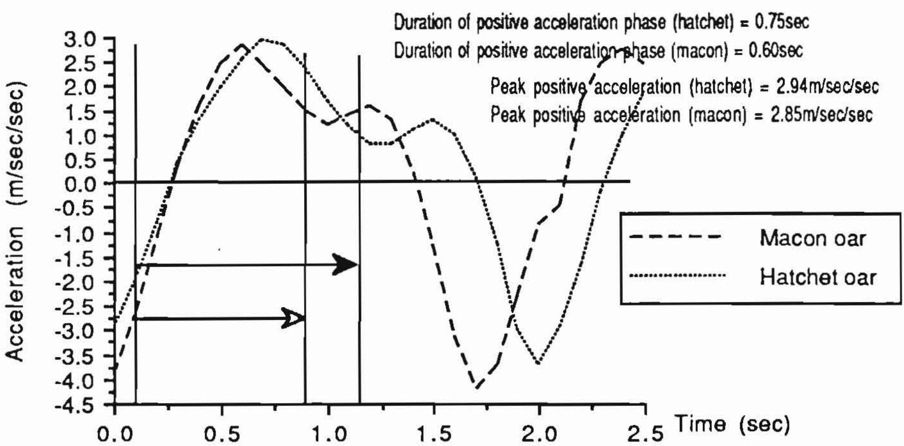

Figure 1. Acceleration resulting from a stroke using the hatchet or macon oars (drive phase - entry to release of blade macon= ——▷ hatchet= ——►).

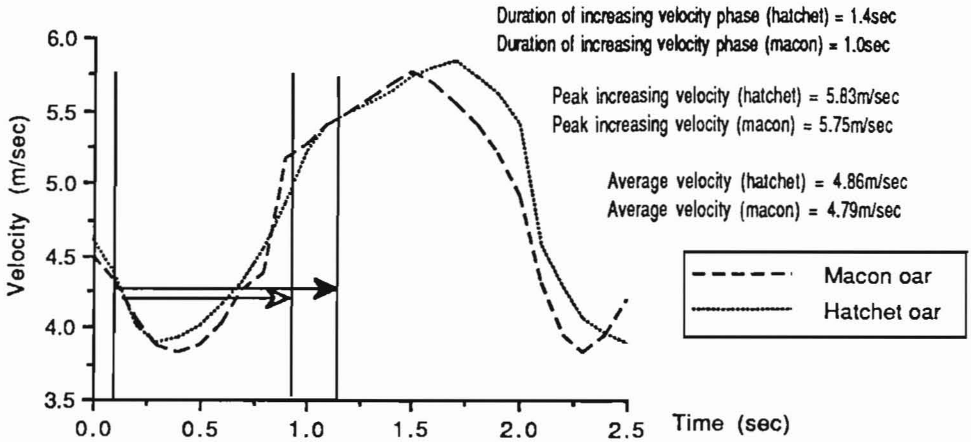

Figure 2. Velocity resulting from a stroke using the hatchet or macon oars.

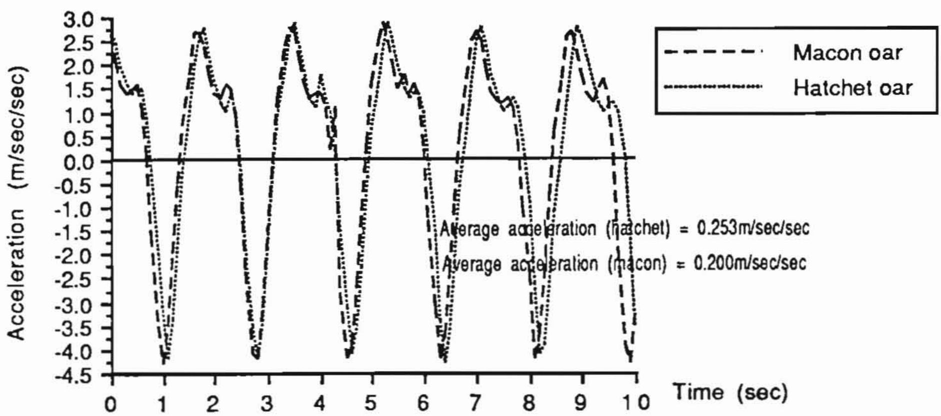

Figure 3. Acceleration resulting from a series of strokes using the hatchet or macon oars.

DISCUSSION

Performance in rowing is based on moving a racing shell and its occupant over a required distance in the least amount of time. Stroke efficiency, either from a technique or equipment standpoint is critical. To these ends, diagnosing the characteristics of boat motion (acceleration, velocity and impulse) can aid in evaluating stroke efficiency and appropriateness of equipment. Propulsion of the rowing craft has been successfully analyzed using accelerometers (Duchesnes et al., 1987). With all other variables remaining constant, these devices can enable the coach or scientist to measure the movement of the racing shell using different oar designs. Oars designed to reduce slippage translate into a greater amount of force transferred from the musculature of the athlete to the blade of the oar in the opposing linear horizontal direction (propulsive force). Equipment designed to reduce slippage aids in this process of stroke efficiency. Although the study has not confirmed that the dynamics of the hatchet oar reduces slippage, the controlled conditions of the test trials has allowed for the comparison of kinematic and kinetic profiles of the two oars. With repeated full motions with the hatchet oar using the same boat, athlete and performance criteria, the singular and compiled data would suggest that the shape and length of the hatchet oar is related to propulsive efficiency.

CONCLUSIONS

These preliminary quantitative findings would suggest that the hatchet oar design is more efficient than the macon oar design in terms of the biomechanical parameters investigated, for this rower, in this single scull. Further, more elaborate investigations are needed to substantiate these findings over the entire race in order to determine the physiological effects of the biomechanical alterations. This device may prove to be an important analytical tool in helping to determine the most effective oar for each athlete, assess as it relates to each athletes boat design, and to improve technique.

REFERENCES

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