Motions of a rower in a scull boat

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Abstract

Longitudinal oar-forces on the swiel support, longitudinal forces on the stretcher and the boat speed were measured. Boat speeds were in the range 2.23~3.37(m/s), oar-forces were −113.4~604.7(N), and forces on the stretcher were −57.6~283.6(N). Motions of the rower's center of mass for the boat were calculated over a series of 2 strokes with the obtained values using the equation of motion. The rower's speeds for the boat were −0.51~0.59(m/s), and the moving width of the rower's center of mass was smaller than 0.35(m).

KEY WORDS: *rowing, scull boat, motion of rower.*

Introduction

Recently the mechanical values of rowing, such as oar-force and boat acceleration, have been measured by a CPU system in the boat [1,2].

We measured the longitudinal oar-forces on the swiel support, longitudinal forces on the stretcher, and the boat speed. With these obtained values, we calculated the motion of the rower's center of mass for the boat.

Measurements

The rower was a 19 year-old female. Her body weight was 55.25kg. She had been rowing for 6 years. Longitudinal oar-forces on the swiel support were measured with a load cell positioned on the back tie. The stretcher was constructed with 4 load cells on the body of the boat. The longitudinal forces on the stretcher were obtained from these load cells. The boat speed was measured with the output voltage of Nielsen-Kellers' "Coach box". The calibration of the speed sensor had been made in a swimming flume. The output voltage of force and speed sensor was amplified. Amplified voltages were converted with an A/D converter. Digital signals were connected to the 486 CPU (100MHz) board. Measurements were made at 30Hz. The values obtained for the force and the speed for a series of 2 strokes are shown in Fig.1.

Equation

The following forces act on the rower's center of mass in the direction of the boat's movement: (a) the reaction force of the boat's stretcher, R_s ; (b) the force of the oar- handle reaction, R_h ; (c) the reaction force of the sliding seat, R_{sl} ; and (d) the force of air resistance, F_a . Let M and V be the rower's mass and the speed of the rower's center of mass respectively, so the following equation

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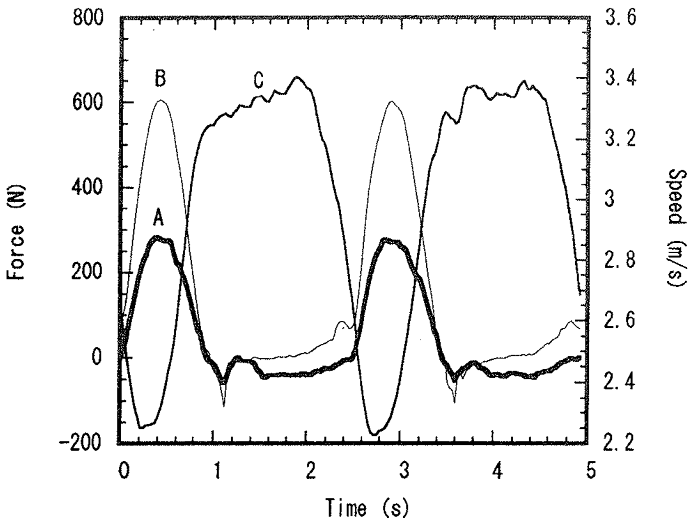

Fig.1. Measured A,reaction forces of the stretcher; B,forces on the swiel support; C,speeds of the boat.

of motion can be written with the accepted symbols.

$$M\, dV(t)/dt = R_s(t) - R_h(t) - R_{sl}(t) - F_a(t) \qquad (1)$$

During rowing, the rower's center of mass moves together with the boat and at the same time changes its location in relation to the boat. The speed of the rower's center of mass, V, is decomposed by the speed of the boat, V_b, and the speed of the rower's center of mass for the boat, V_r.

$$V(t) = V_b(t) + V_r(t) \qquad (2)$$

We suppose that the force of the oar-reaction, R_h, is equal to cF_o, where c is a coefficient and F_o is the force on the swiel support. Ignoring R_{sl} and F_a in Eq.(1) on the assumption that their values are small, the following equation is introduced.

$$M\, dV_r(t)/dt = R_s(t) - cF_o(t) - M\, dV_b(t)/dt \qquad (3)$$

Calculation and Results

The measured boat speeds were smoothed by the least square method using equations of the fourth degree. Measured and smoothed speeds are shown in Fig.2.

For the calculation of Eq.(3), smoothed boat speed, measured forces on the stretcher, and measured oar-forces on the swiel support were used. The acceleration of the boat was calculated analytically with the smoothed boat speeds. To solve the coefficient in Eq.(3), we made it a condition that the speeds of the rower's center of mass for the boat were equal at the beginning and the end.

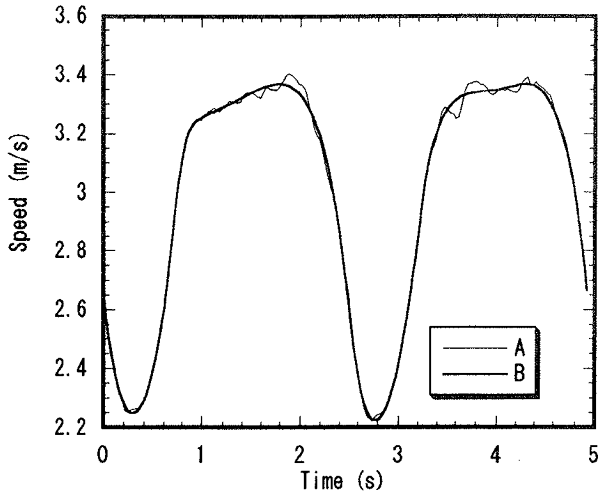

Fig.2. A,measured speeds; and B,smoothed speeds.

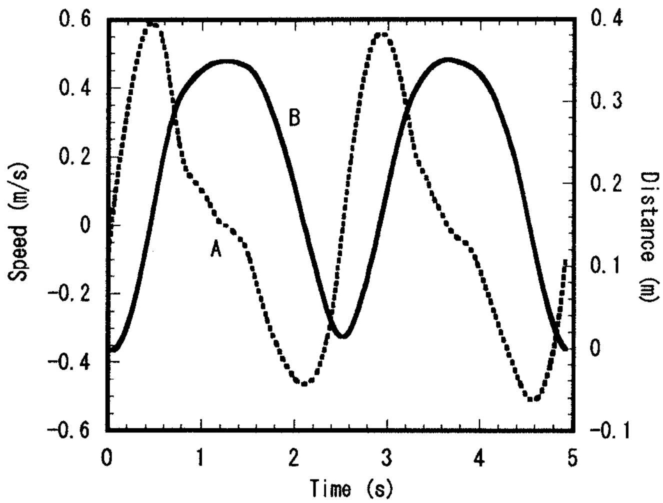

Fig.3. A, speeds of the rower's center of mass for the boat; B, displacements of the rower's center of mass in the boat.

Thus obtained c was 0.35. The speeds of the rower's center of mass for the boat were obtained with the accelerations of the rower's center of mass using numerical integration. The rower's displacements in the boat were not always equal at every stroke. In this study, however, the rower's position in the boat at the beginning and the end were set equally. The displacements of the rower's center of mass in the boat were obtained with the numerical integration of the speeds of the rower's center of mass. In Fig.3, speeds and displacements of the rower's center of mass are shown.

Conclusion

The boat speed, the oar-force on the swiel support, and the force on the stretcher were measured. Solving the equation of the motion of the rower with these measured values, the speeds of the rower's center of mass for the boat and the position of the rower's center of mass in the boat were obtained. These obtained data are useful for rowing training.

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References

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スカルボート上の漕手の運動

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要約

クラッチにかかるオールの進行方向の力，ストレッチャーへの進行方向の力およびボートスピードが測定された。測定値をもちいて，運動方程式を解くことにより，ボート上の漕手の重心の運動が，2ストロークにわたってもとめられた。得られた値は，ボートスピード：2.23～3.37(m/s)，オールの力：−113.4～604.7(N)，ストレッチャーにかかる力：−57.6～283.6(N)，ボートに対する漕手のスピード：−0.51～0.59(m/s)，ボート上の漕手重心の移動距離は 0.35(m)以下であった。

KEY WORDS: rowing, scull boat, motion of rower.