The pelvis during the shifting of the pelvis, it is also shown towards the supporting leg. It is small dysplasia and small leg. The fact that the resultant is for such surprising result the the supporting leg the consequently in case braces in the hip joint articular acetabular edge (Fig.3a).

It can be concluded that should be encouraged to use of the non-weight-bearing of the body towards the unloaded to an optimum moment is decreased.

DYNAMIC ANALYSIS OF ROWING IN MODEL OF MULTI-BODY SYSTEM

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INTRODUCTION

Rowing is a race of the common motion between human body and apparatus. It is a complex motion. It is very difficult to exactly analyze this motion. The author has never seen the report of complete analysis for this motion.

In this paper we base on experimental measure, found the model of rowing in method of multi-body system and define functional relation between technical parameters and moving condition. The result provides theoretical basis for raising sport level.

MECHANICAL MODEL

According to the property of rowing, this system is simulated as a model of six rigid body in planar domain (See Fig.1). B1-B4 denote human body, B1 denotes shanks, B2 thighs, B3 hood and trunk, B4 arms, B5 car, B6 rowboat. They join to each other with a joint. Each joint is respectively Oi (i=1,...,5). Distance between a joint and its adjacent joint respectively is li (i=1,...,5). Where li is variable, because it isn't real itself, but that it is projection In the vertical plane. Let OA = l6. The distance between O1 and mass center of B1 respectively is r1. The mass of each body is mj. The moment of inertia in mass center is Jj. The origin of coordinate system is fixed in rowlock. The x axis parallel to plane of water. Distance between O and O1 is a1 in x axis. Distance between O1 and end of slide, seat of slide respectively is a1, (a-s). The oar handle, trunk B3 respectively cross at β, α to x axis. Vertical swing angle of the rowboat is θ. According to experience of coaches, it is key techniques of rowing to control slide moving and stroking. So that, s (denote slide moving) and θ (denote stroking angle) are defined as controlled functions. For two rowers having same power, if their controlling functions s, θ are different, they will have different effect on rowing. Thus, we defined various groups s, θ according to measuring data in high speed camera, found differential equations described rowing. Solving these equations, we obtain solved functions v and θ governed by various s, θ. Then we can define optimum group s, θ as normal technical function, by which judge sport level of athlete. Because rowing is periodic motion, the motion is only analyzed during one period in this paper.
ANALYSIS OF FORCE EXERTED ON SYSTEM

Resultant exerted on system is  \( F + f + P + Q \)
where  \( F \) is the force of pushing oar from water (denote total active force) acts on center of oar blade. Its directional vector crosses right angle to oar handle. It is difficult to count its magnitude which may be approximated as

\[
F = K_1(\beta) l_0 \sin \beta - v \]

(1)

where  \( v \) is velocity of boat. The  \( K_1 \) is assumed constant in this paper, it relate to characteristic of fluid, shape of moving body and surface area of the boat under water. In order to simplify problem,  \( K_1 \) is defined on basis of article [2].  \( K_1 = 39.6 \) N/M.  \( f \) is denoted as resistance on the boat. Its direction is opposite in velocity  \( v \). Its magnitude can be approximated as

\[
f = K_2 v, \quad K_2 = 3.27 \text{ n/m.} \]

\( P \) is gravity, acts on mass center of the system.  \( Q \) is buoyancy acts on center of shape of the boat, which configuration of rowlock (namely origin 0). Its magnitude can be approximated as constant, because change of the system moving is very small in direction of  \( y \) axis. The system is simulated as a model composed of six rigid body, six joint and a single constraint. In consideration of variable  \( \varphi \), the system is defined as six degree of freedom model. According to the analysis of film,  \( \alpha \) and  \( \beta \) are determined as following constraint relationship:

\[
\beta = (14\alpha / 5) - (166\pi / 180) \]

(2)

Thus there is five degree of freedom in this system. Let  \( x, y, \theta, \beta, s \) be generalized coordinated,  \( \bar{\alpha} = h(\bar{t}), \quad s_1 = f(\bar{t}) \) be controlled functions. We will find equations of momentum theorem and angle momentum theorem.

EQUATIONS

Because motion of the system is very small in direction of  \( y \), we only derive the equations of momentum theorem in  \( x \) and angle momentum theorem:

\[
\Sigma m_i \ddot{x}_i = F_x; \quad dH/dt = M \quad (i = 1, 2, \ldots, 6) \]

(3)

where  \( F_x \) is resultant in  \( x \) axis.  \( H \) is total angle momentum.  \( M \) is total momentum of external force about origin O. Let  \( O - x y \) plane as complex plane, the  \( r_i \) is distance from  \( O_i \) to  \( c_i \). Suppose  \( \theta \) is small enough to be neglected its effect for the system in direction of  \( x \). Configuration of center  \( c_i \) of each body is given by:

\[
c_1 = \alpha_1 - bi + \gamma_1 e^{i(\theta_1 - \gamma)}; \quad c_2 = s - bi + \gamma_2 e^{i(\theta_1 - \gamma)}; \]

\[
c_3 = s - bi + \gamma_3 e^{i(\alpha - \gamma)}; \quad c_4 = [s - bi + \gamma_3 e^{i(\alpha - \gamma)}] + l_5 e^{i(\beta - \gamma)} / 2; \]

\[
c_5 = r e^{i\beta} \]

(4)

Then we find out the equal

\[
H = \Sigma (m_i \gamma \hat{e} x_i) \]

where  \( a_1 \) is obstacle angle:

\[
a_1 = \theta_1 + \gamma; \quad \varphi_1 = \gamma \]

Substitution from (4), (5),

\[
\Sigma m_i \dot{x}_i = \Sigma m_i \dot{\theta}_i \]

where last item is moment.

The known constant  \( a = 0.08 \text{ m}, J_i \) were obtained rower Xu :  \( J_1 = 0.28 \text{ kg-m}^2; \quad J_5 = 3.06 \text{ kg-m}^2 \). Let  \( 0 \leq t \leq 0.8, v_0 = 0.5 \) group solutions  \( v, \theta \) after stroking. The result are obtain functions, the variation is increasing is slower. If during special time, it is group, the conclusion is

CONCLUSION

According to above

(1) It is effective to reduce

(2) To improve technique

(3) It is the most effective

(4) The theoretical result...
where $\theta_1$, $\theta_2$ are expressed in generalizes coordinate $s$, governed by geometric relation of Fig. (1):
\[
\cos \theta_1 = -\left[ \frac{1}{2h_1} \left( \frac{a^2 + (a - s)^2}{2} \right) \right]
\cos \theta_2 = \left[ \frac{1}{2h_2} \left( \frac{a^2 + (a - s)^2}{2} \right) \right]
\]
Then we find out the equation of angle momentum theorem:
\[
\mathbf{H} = \sum (m_l + c_l \times c_l + J_l) \mathbf{a}_l
\]
where $a_l$ is absolute angle velocity of each component body:
\[
a_1 = \dot{\theta}_1 + \theta ; \quad a_2 = \dot{\theta}_2 + \theta ; \quad a_3 = \alpha + \theta ; \quad a_4 = \omega_5 = \theta ; \quad a_5 = \beta + \theta
\]
Substitution from (4), (5), (6) into (3), simplifying formulations are obtained:
\[
\mathbf{d} \left[ \sum (m_l c_l \times c_l + J_l a_l) \right] / dt = \sum m_l g \cdot \text{Re}(c_l) + \mathbf{fb} - F_{R_l} - K_{2l0} (l\theta) dt
\]
where last item is moment of viscosity resistance, $l$ is distance from $O$ to $dl$.

The known constants were measured by $a = 0.38 \text{ m} ; b = 0.16 \text{ m} ; a = 0.08 \text{ m}$. $J_l$ were obtained by Hanavan's report [1] and measuring parameter of rower Xu: $J_1 = 0.28 \text{ kg-m}^2$; $J_2 = 0.48 \text{ kg-m}^2$; $J_3 = 4.9 \text{ kg-m}^2$; $J_4 = 0.31 \text{ kg-m}^2$; $J_5 = 3.06 \text{ kg-m}^2$; $J_6 = 98.29 \text{ kg-m}^2$. Refer to article [2], $\beta(t)$, $s(t)$ can be approximately described as linear, cosine (sine), square functions during the stroking. They are give by:
\[
\beta_1 = 5 \pi t / 6 + \pi / 6 ; \quad \beta_2 = 5 \pi \sin(\pi t / 2) / 6 + \pi / 6 ; \quad \beta_3 = \pi / 6 + 5 \pi t^2 / 6 ;
\]
\[
s_1 = -0.6t + 0.7 ; \quad s_2 = 0.6 \cos(\pi t / 2) + 0.1 ; \quad s_3 = 0.6t^2 - 1.2t + 0.7
\]
Let $0 \leq t \leq 0.8$, $v_0 = 0.5 \text{ m/min}$, $\theta_0 = 0$ and substitute (8) into (7). We obtain nine group solutions $v, \theta$ after counting. (See Fig.2)

The result are obtained by analyzing as following: If $\beta, s$ are defined as linear functions, the variation of $\theta$ is small. It means that the boat sailing is smoother, but increasing is slower. If $s$ is square function, the curve of velocity $v$ will decrease during special time. It is unfavorable for rowing. After analyzing the data of each group, the conclusion is clear: $\beta_3 s_2$ is defined as optimum group.

CONCLUSION

According to above analysis, we obtained these conclusions as following:
(1) It is effective to research rowing in the method of multi-body mechanics.
(2) To improve technique of controlling slide and stroking, it enables sport level to raise in a big margin.
(3) It is the most effective as $\beta$ is denoted by square curve, $s$ by cosine curve.
(4) The theoretical results corresponds to feeling of coaches.
Fig 1: Mechanical Model of Rowing

Fig 2: Velocity V of Boat and Vertical Swing Angle θ

REFERENCES


A MODEL FOR THE SIMULATION OF DROP JUMPING

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INTRODUCTION
Drop jumps may be viewed as a system with a sufficient auxiliary mass of internal viscera due to the jumping mass. Minetti and Bell (1984) described the total body mass, oscillating during hopping and thus simulating jumping, but also as an influence of jump by mathematical models.

METHODS
The model (Fig. 1) consists of a damper, where mass m, presents the external container, x, and the displacements of m, and the position of equilibrium, B1, is defined as an attachment of other parts of the body. The body was described with two differential equations:

\[ m_1 \ddot{x}_1 - B_1 \dot{x}_1 + K_1 x_1 = 0 \]
\[ m_2 \ddot{x}_2 - B_2 \dot{x}_2 - K_2 x_2 = 0 \]

where m1 presented the mass of the external container, x1, and m2, mass of internal viscera, x2, and B1 and B2 damping coefficients, K1 and K2 the stiffness coefficients.

Numerical solution was performed by MATLAB (The MathWorks Inc.). The vertical displacement of centre of gravity of both masses was systematically at constant K1 and K2.

Each jump was simulated in a systematic phase. The maximum jumping height was calculated from the horizontal changes of centre of gravity in aerial phase, calculated as:

\[ h = \frac{1}{2} g t^2 + v_0 t \]

where g is the acceleration due to gravity, t is the time elapsed, and v0 is the initial vertical velocity at takeoff.