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La la fuck kick dynamics model and its application in research

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ABSTRACT

As time progresses, also developed rapidly, and is valued by many enterprises in order to make the public more health science practice operation, this paper!! Fuck the high kick was studied, and got the la-la-la gymnast high kick when the rotational inertia of the right leg, also through the dynamics analysis to find the speed of the athletes of leg and hip, knee and ankle. And that la la gymnast doing high kicking the right leg of potential energy and kinetic energy, when the athletes by hip effective braking effect can increase the knee the momentum of the similarly brake knee momentum transfer to ankle again, have accelerated the effect of ankle joint. So this article get the calf angular velocity should be larger than the thigh of angular velocity, it will be more conducive to the acceleration of the knee joint. And also can see la-la-la gymnast was in a high kick to speed up the leg of the leg to make crus of the angular velocity is greater than the thigh of the angular velocity to drive the acceleration of the knee, ankle when landing would be so as the athletes speed and large buffer time lead to smaller lesions in the ankle and knee and thigh, but relative to the ankle, knee and thigh speed is relatively small, and the buffer time is longer, so the damage rate will be slightly lower.

KEYWORDS

Moment of inertia of the analysis; The momentum analysis; Dynamic analysis; The momentum transfer; Diomechanics.

INTRODUCTION

Cheer leading, Chinese named hold, Cheer for cheering, for the meaning of... Come on. So!! Fuck appearing in the early tribal rituals, are aimed at encouraging or incentive to men of war, hunting at the time, and with the meaning of hope warriors can triumph. And la la fuck officially became a sports project is appeared in the one hundred years ago in the United States, throughout the various groups of competitive sports in the United States. La-la-la fuck from then just cheer, now turned into a very popular sport. Because la-la-la hold collective exercise, dance, music, fitness, entertainment, and mainly in the form of collective sports, so fuck with a strong universality, to promote its development is very rapid. Fuck belongs to the scope of the aerobics, but due to fuck for aerobics is simpler, so were mostly as a ball game and other games!! Fuck during halftime performance of the team. But with the development of The Times and the improvement of living standards, la la fuck also gradually becomes a project to make the game.

Because la-la-la fuck with medical treatment, health care, fitness fitness and entertainment, etc. The practical value, so as to ensure the material in the era of more and more get the favour of the more and more people. Appeals to the consumption of all age groups, and many television stations have also made to competition, universal feature program, the content of attention by many enterprises. Modern la-la-la fuck is a combination of dance, slogans, partner stunt actions such as technology, and cooperate with the music, clothing, team changes and marked items such as elements, abide by the rules of the game for the unit with the team for the game's movement, also known as competitive cheerleading. La-la-la cao commonly used hand have separated type and combined type, ballet hand type, punch, palm and Spanish dance hand type, etc. Its mostly from ballet and modern dance, disco, absorbed and developed in martial arts. And la la fuck every other part of the action and aerobics also similar, the basic form to stretch, bend, turn around, and placed, lift and vibration. Which show the wavy movement, swinging, flex, swivel, round ring, leapfrog, dance and so on. In this article are for la la leg movements through the analysis of and research into a high kick.

THE ESTABLISHMENT OF THE MODEL AND SOLUTION

Cheer leading athletes need to keep upright, waist, and then the right foot (left foot) ground to move the center of gravity to left foot (right), her hands rested on her hips or lift, the left leg (right leg) to hip for axis on the knees; Then deep hip to knee up to chest, round the knee joint and make the left (right) leg straight up, and finally to lift the right leg unbend above his head, finally back your left leg (right) when they high kick. Figure 1 is the whole process of cheer leading high kick.

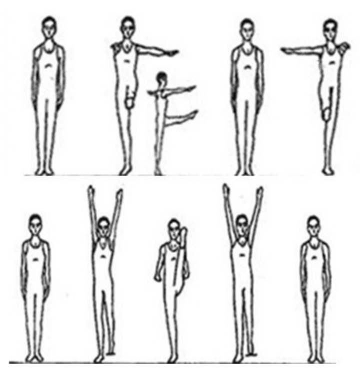

Figure 1 : Cheer leading high kick schematic diagram

Dynamics analysis of Cheer leading high kick

Moment of inertia of refers to the production of the measure of the inertia when a rigid body move round the axis during the fixed axis rotation, which is only related to the rigid bodies' shape, quality, and the location of the axis, and has nothing to do with the parameters such as angular velocity.

When cheer leading athlete does kick jump, they need to let the body upright, use the single leg jump, meanwhile, the other leg kicks out in straight forward, this process can regard the athletes' right leg as a rigid body which is doing the fixed axis rotation around the hip joint, Figure 2 is the Athletes' right leg rotation diagram.

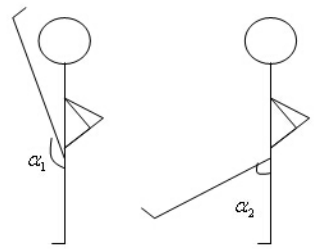

Figure 2 : the schematic diagram of athletes' right leg's rotation of high leg lifts

Cheer leading athlete's moment of inertia is: $I = \Sigma M_i Q_i^2$

But due to the continuous of all parts of the body, we regard the cheer leading athlete's body as a rigid body of continuous distribution of quality, so that: $I = \iiint_v Q^2 dm = \iiint_v Q^2 \rho dV$

Among them M_i is the quality of all parts of the body, the distance of each part of the athletes to the axis is Q, The density of the human body is ρ. Cheer leading athlete's right leg rotation tensor $\overset{\leftrightarrow}{S}_c$ is: $\overset{\leftrightarrow}{S}_c = \iiint_v \rho(Q^2 \overset{\leftrightarrow}{E} - \vec{Q}\vec{Q})dV$ The radius vector expression of Athletes' arbitrary point on the body O is $\vec{Q} = Q_1 \vec{e}_1 + Q_2 \vec{e}_2 + Q_3 \vec{e}_3$;The product of two vectors is $\vec{Q}\vec{Q}$; Unit tensor of athletes' Body are : $\overset{\leftrightarrow}{E} = \begin{bmatrix} 1 & & \\ & 1 & \\ & & 1 \end{bmatrix}$, is Unit orthogonal curvilinear frame.

The torque equation of rotation tensor of Cheer leading high kick

Joint torque vector of Cheer leading high kick is $\Sigma \vec{j}_c$, $\vec{\omega}$ is the angular velocity of the Athletes in the inertial vector of dynamic system, The angular acceleration vector is $\vec{\theta}$, so that the rotation tensor torque equation of Cheer leading high kick is: $\Sigma \vec{j}_c = \overset{\leftrightarrow}{S}_c \bullet \vec{\theta} + \vec{\omega} \times \overset{\leftrightarrow}{S}_c \bullet \vec{\omega}$

Now we project the torque equation to the three coordinate system x, y, z on the shaft and get the torque equation of the athletes' right leg in the every axis direction. When the athlete is doing high kick, the external torque of right thigh rotation N_1 is: $N_1 = \chi_1 \bullet I_1$

Among them χ_1 is the angular acceleration of right thigh, the rotational inertia of the right thigh is I_1. And: $I_1 = \frac{M_1 R_1^{\,2}}{2}$ R_1 is the radius of the right thigh, M_1 is the quality of right thigh, The angular acceleration of right thigh χ_1 is: $\chi_1 = \frac{dw_1}{dt} = \frac{d^2\alpha_1}{dt^2}$.

Since the initial angular velocity of the right lower leg is the angular velocity of right thigh χ_1, so that the angular velocity of the right lower leg χ_2 is : $\chi_2 = \frac{dw_2}{dt} + \frac{dw_1}{dt} = \frac{d^2\alpha_2}{dt^2} + \frac{d^2\alpha_1}{dt^2}$

Now we regard of the cheer leading athletes' right legs as two rigid bodies and build the hip joint and knee joint up to three Degrees of freedom model, which is shown in Figure 3.

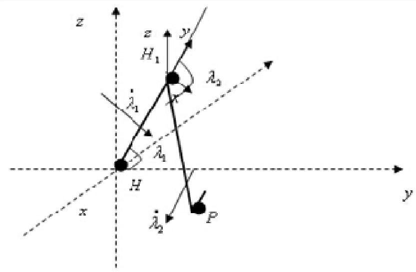

Figure 3 : Two schematic diagram of rigid body with three degrees of freedom of sportsman' right leg

In Figure 3, point H is hip joint, H_1 is knee joint, length of thigh and calf respectively is h_1, h_2, the anatomical angle is λ_1, λ_2. And H and H_1 both is three degrees of freedom, and three dimensional vector is $\dot{\lambda}_1, \dot{\lambda}_2$.

As for the reference system on earth, $\dot{\phi}_1$ and $\dot{\phi}_2$ are angular speed with respect to the reference system of athletes' thigh and calf. Speed of knee joint is $\dot{\lambda}_2$, and $\dot{\lambda}_2 = \dot{\phi}_2 - \dot{\phi}_1$.

When cheer leading athletes are doing high kicks, the angular speed of thigh, calf and knee joint all can affect angular speed of ankle P. Because thigh and calf are rotatable, we can know that when knee joint H_1 is doing circular motion, it can drive calf do translation and rotation with respect to coordinate system $H_1 - xyz$. Rotation and translation are relatively independent, so they will not affect another' motion vector of hip joint and knee joint and angular speed of calf. Ankle P' angular speed is relative to its speed with respect to inertial coordinate and line speed of knee joint with respect to coordinate system, i.e. $\vec{C}(\vec{H}_1)_G = \dot{\lambda}_1 \times \vec{V}_1 = \dot{\lambda}_1 \times \vec{V}_1$, $C(\vec{P})_L = \dot{\lambda}_2 \times \vec{V}_2$, in the formula, $\vec{C}(\vec{H}_1)_G$ is knee joint' velocity vector relative to coordinate system. $C(\vec{P})_L$ is speed of P with respect to H_1. $\dot{\lambda}_1, \dot{\lambda}_2$ respectively is angular speed of hip joint H and knee joint H_1. $\vec{V}_1$ is position vector from hip joint to knee joint. $\vec{V}_2$ is position vector from knee joint to ankle P.

In order to get speed $\dot{p}_G = \vec{C}(\vec{P})_G$ of ankle P with respect to earth, we must get the influence of local motion of thigh and calf on joints at first of all. According to vector theorem, we can see $\dot{P}_G = \dot{\lambda}_1 \times \vec{V}_1 + \dot{\lambda}_2 \times \vec{V}_2 + \dot{\lambda}_1 \times \vec{V}_2$, $\dot{P}_G = \dot{\lambda}_1 (\vec{V}_1 + \vec{V}_2) + \dot{\lambda}_2 \times \vec{V}_2$. After simplifying: $\dot{P}_G = \vec{P}_G \times \dot{\lambda}_1 + \dot{\lambda}_2 \times \vec{V}_2$. Position vector of ankle in the coordinate system is $\dot{P}_G$. Vector product $\vec{P}_G \times \dot{\lambda}_1$ is the speed that hip joint makes ankle make. In the same way, vector product $\dot{\lambda}_2 \times \vec{V}_2$ is speed that knee joint makes ankle make.

To further clearly describe the speed relationship among hip joint, knee joint and ankle, the relationship of the angle of hip joint and knee joint and the position of ankle in Figure 3 can be writed as following:

$$\begin{cases} x_p = V_1 \cos \lambda_1 + V_2 \cos(\lambda_1 + \lambda_2) \\ y_p = V_1 \sin \lambda_1 + V_2 \sin(\lambda_1 + \lambda_2) \\ z_p = V_1 \cos \lambda_1 + V_2 \sin(\lambda_1 + \lambda_2) \end{cases}$$

To do differential angle of hip joint and knee joint, the relationship with position vector of ankle can be differentiate from the above formula:

$$\begin{cases} dX = \dfrac{\partial X(\lambda_1, \lambda_2)}{\partial \lambda_1} d\lambda_1 + \dfrac{\partial X(\lambda_1, \lambda_2)}{\partial \lambda_2} d\lambda_2 \\ dY = \dfrac{\partial Y(\lambda_1, \lambda_2)}{\partial \lambda_1} + \dfrac{\partial Y(\lambda_1, \lambda_2)}{\partial \lambda_2} d\lambda_2 \\ dZ = \dfrac{\partial Z(\lambda_1, \lambda_2)}{\partial \lambda_1} + \dfrac{\partial Z(\lambda_1, \lambda_2)}{\partial \lambda_2} d\lambda_2 \end{cases}$$

To diverse this into matrix form:

$$\begin{pmatrix} dX \\ dY \\ dZ \end{pmatrix} = \begin{pmatrix} \dfrac{\partial X(\lambda_1, \lambda_2)}{\partial \lambda_1} & \dfrac{\partial X(\lambda_1, \lambda_2)}{\partial \lambda_2} \\ \dfrac{\partial Y(\lambda_1, \lambda_2)}{\partial \lambda_1} & \dfrac{\partial Y(\lambda_1, \lambda_2)}{\partial \lambda_2} \\ \dfrac{\partial Z(\lambda_1, \lambda_2)}{\partial \lambda_1} & \dfrac{\partial Z(\lambda_1, \lambda_2)}{\partial \lambda_2} \end{pmatrix} \begin{pmatrix} d\lambda_1 \\ d\lambda_2 \end{pmatrix}$$

According to the nature of the matrix and the cross product method, we can write above formulalike the following: $d\vec{P}_G = \vec{Q} d\vec{\lambda}$. In that formula, $\vec{Q}$ is

$$\vec{Q} = \begin{pmatrix} \dfrac{\partial X}{\partial \lambda_1} & \dfrac{\partial X}{\partial \lambda_2} \\ \dfrac{\partial Y}{\partial \lambda_1} & \dfrac{\partial Y}{\partial \lambda_2} \\ \dfrac{\partial Z}{\partial \lambda_1} & \dfrac{\partial Z}{\partial \lambda_2} \end{pmatrix}$$

$\vec{Q}$ is the differential relationship between the infinitesimal displacement of joint angular displacement and ankle in the current structure. Bring the matrix relation into the above formula, we can see:

$$\frac{d\vec{P}_G}{dt} = \vec{Q} \frac{d\vec{\lambda}}{dt} \text{ or } \vec{P}_G = \vec{Q}[\dot{\lambda}_1, \dot{\lambda}_2]^T$$

Bring it into the relative velocity formula of ankle, we can get:

$$\dot{P}_G = \begin{pmatrix} \frac{\partial X}{\partial \lambda_1} & \frac{\partial X}{\partial \lambda_2} \\ \frac{\partial Y}{\partial \lambda_1} & \frac{\partial Y}{\partial \lambda_2} \\ \frac{\partial Z}{\partial \lambda_1} & \frac{\partial Z}{\partial \lambda_2} \end{pmatrix} [\vec{\lambda}_1, \vec{\lambda}_2]^T \dot{\lambda}_1 + \dot{\lambda}_2 \times \vec{V}_2$$

From the analysis we can know when cheerleading athletes are doing high kicks, in order to make motion coherence good, they must fast the foot speed. Only in this way, P_G can get maximum of velocity projection in the z direction, and only when λ_1, λ_2 is satisfied the constraint condition $40° < \lambda^1 + \lambda^2 < 90°$ and $0 < \dot{\lambda}_1 < \dot{\lambda}_2$, speed of ankle P can get maximum on vertical plane. This requests the flexion degree of athletes' left thigh calf cannot be more than $40°$, and the shifting time must be short when athletes are doing preparation of high kicks. If leg' submergence flexion degree is too much, the muscles can be loose because of the shrink of long time on muscles.

When λ_1, λ_2 meet their constraint condition, with the increasing of $\dot{\lambda}_1$ and $\dot{\lambda}_2$, the change rate of anatomical angle of thigh and calf in unit time when athletes are doing high kicks will requested to reach maximum, and during this time, the change rate of anatomical angle of calf must be bigger than thigh'. According to can transfer theorem of rigid body, we can see that when right leg leave ground, the angle between thigh and calf is $180°$, and power will convey along thigh axis to calf. But because the thigh and calf are connected, so that the power will lose during the transfer process. So the angular speed of calf bigger than thigh' is more benefit to the acceleration of knee joint. And from the mechanical analysis of athletes' high kicks, we can see that when athletes are doing high kicks, they need to speed up calf' foot speed to make the calf' angular speed bigger than thigh' in order to fasten knee joint' acceleration. In that athlete' ankles, knee joints and thighs will be injured because the ankles' speed is too much and the buffer time is too short when athletes reach the ground. But as far the speed of ankles, knee joints and thighs era relatively little, and the buffer time is much longer, so the rate of injury will be less.

CONCLUSION

Through the research, this text get right leg' moment of inertia when athletes are doing high kicks, and know the speed relationship among athletes' thigh, calf, hip joint, knee joint and ankle through analysis of thermodynamics and kinetics. And we already have known that when athletes are doing high kicks, the right leg produces potential energy and kinetic energy i.e. athletes can increase knee joint' kinetic energy by hip joint' affective braking effect. In the same reason, through knee joint' braking effect to transfer momentum to ankle to get the result to fasten ankle. So that this text knows that angular speed of calf should be bigger than thigh', and it is benefit to knee joint' acceleration. And we can find that when cheerleading athletes are doing high kicks, they should speed up calf' foot speed to make the angular speed of calf bigger than thigh' in order to drive knee joint' acceleration. In those athletes' ankles, knee joints and thighs will be injured because the ankles' speed is too much and the buffer time is too short when athletes reach the ground. But as far the speed of ankles, knee joints and thighs era relatively little, and the buffer time is much longer, so the rate of injury will be less.

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