Hiley, M.J. and Yeadon, M.R. 2001. Swinging around the high bar. Physics Education 36 , 1, 14-17.

The high bar is one of six pieces of equipment used in Men's Artistic Gymnastics. The basic movement in competitive routines is the giant circle in which the gymnast tries to remain ex

In the case of starting from a still handstand $\omega_0 = 0$ rad.s^{-1} and taking m = 60 kg, g = 9.81 m.s^{-1}, r = 1.0 m and $I_G = 10$ kg.m^2 gives $\omega_1 = 5.8$ rad.s^{-1} which is the correct order of magnitude although a little larger than measured values.

The reaction force R exerted on the hands can be calculated at the lowest point of the circle using Newton's Second dcth

Suppose we estimate d_1 = 0.02 m and d_2 = 0.10 m. This gives ω_2 = 5.6 rad.s^{-1} and R = 4.5 mg at the lowest point. These values are closer to the actual values of ω = 5.0 rads^{-1} and R = 3.3 mg than previous analysis with a rigid bar. Further improvement can be using an elastic model of the gymnast since gymnasts stretch by 0.15 m during a giant circle.

Weightless

Prior to a dismount the gymnast uses accelerated giant circles to build up angular velocity around the bar. This means that at the highest point the angular velocity can be quite large. If the angular velocity is large enough the gymnast will be "weightless

Once the gymnast reaches the highest point an extension is performed. Again the potential energy is increased by raising the mass centre, although, the kinetic energy is reduced slightly due to the increase in moment of inertia about the bar. If the net increase in potential and kinetic energy during these actions is greater than the loss of energy due to friction, the gymnast will complete the giant circle with more kinetic energy and hence more angular velocity than he started with.

The same point mass model may used to describe the basic technique of the backward giant circle from the perspective of the torque created by the gymnast's weight. During the downswing the gymnast remains extended so as to maximise the effect of the torque, which increases the gymnast's angular velocity about the bar. During the upswing the torque created by the gymnast's weight slows the gymnast's angular velocity. To reduce the effect of the torque during the upswing the gymnast closes his hip and shoulder angles reducing the moment arm of the weight and hence the torque itself (Figure 5).

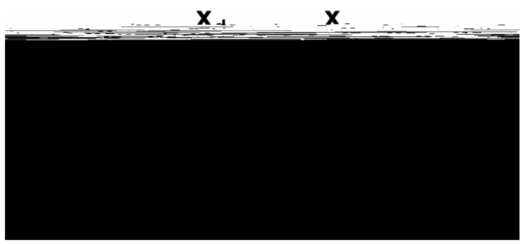

Figure 5. By moving the mass centre closer to the bar during the upswing the gymnast reduces the effect of the torque tending to res

choose to exert. There are two possibilities: either the gymnasts are not strong enough to flex before the lowest point or they choose to work within themselves.

[redacted]

Figure 6. Two flexion actions performed either side of the lowest point of a giant circle.

The same mechanics apply to the extension that the gymnast performs near the highest point. More concentric work is done by extending before the highest point, due to the larger torques that are required. If the gymnast were unable to exert this level of torque he would delay the extension until after the highest point. However, the joint torques involved with the extension are less than those involved with the flexion through the lowest point and so the gymnast is able to extend before the highest point producing a greater increase in energy.

More complex computer simulation models of swinging have been developed (Hiley, 1998) and are currently in use to analyse giant circles used by elite gymnasts at the Sydney Olympics.

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