HORIZONTAL BAR GIANT SWING CENTER OF GRAVITY MOTION COMPARISONS

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The purpose of this study was to compare the trajectory and angular velocity of the gymnast's center of gravity (CG) in three types of overgrip giant swings on the horizontal bar. This was a preliminary study carried out at the Olympic Committee's Biomechanics Laboratory in Colorado Springs. The primary goal of research done at the USOC Biomechanics Laboratory is to help improve the performance of our potential Olympic athletes. Hence, the aim of this study was, from the comparison of the three types of giant swings, to identify some simple, quantitative indicators of good or bad technique during these swings.

Before the study is discussed further, some definitions of terms used are presented:

1) Regular Giant. This is an overgrip giant swing that would commonly be found in the middle of the routine. It is the giant swing that joins skills and is not aimed at accelerating the gymnast. (Figure 1)

2) Dismount Giant. This is the overgrip giant swing which contains the release for the dismount. It is in actual fact only a partial giant swing. (Figure 2)

3) Wind-up Giant. This overgrip giant swing preceeds the Dismount Giant. The gymnast may use one or more of these to accelerate in preparation for the dismount. Hence, the term "wind-up".

Many studies have been done on the overgrip giant swing, (Borms et al 1975, Dainis 1975, Boone 1977, Bauer 1983), however, none so far have looked specifically at the wind-up giant and the dismount giant and their relationship. The dismount itself is probably the most important skill in the routine. It is the last skill the judge sees, and so, leaves a lasting impression. It is also a good method of gaining extra points through ROV (Risk, Originality, Virtuosity). As a result, dismounts have become difficult and dangerous, consequently it was thought prudent to study the factors that set the gymnast up for the dismount, that is, the preceeding giant swings.

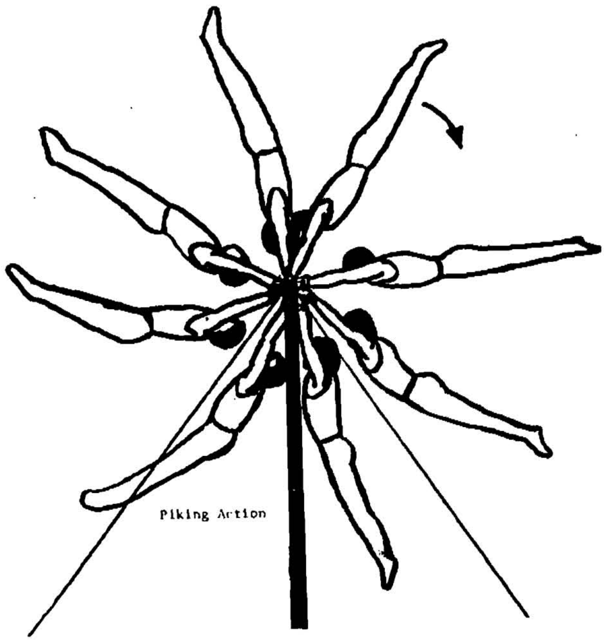


Figure 1. Regular Giant swing

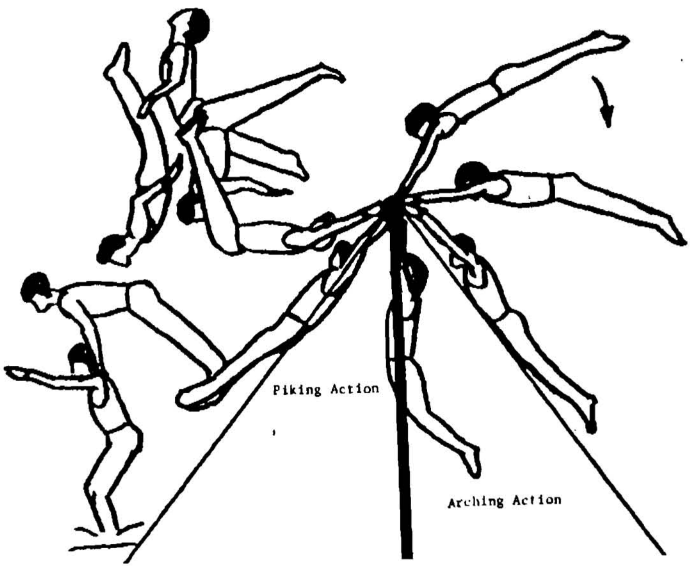


Figure 2. Dismount Giant followed by Layout Dopuble Somersault

The subjects for this study were the High Bar finalists in the National Sports Festival held in Colorado Springs in 1983. All the finalists were filmed from the side at 50 frames per second at a distance in excess of 60 meters. Five of the gymnasts filmed showed all three of the types of giant swings being studied. These five gymnasts had all three of these giants digitized. The data were then smoothed using a digital filter with a cutoff frequency of 10Hertz. The CG was calculated using paramters from Dempster (1955). The path of the CG was graphed and its angular velocity around the bar calculated and analyzed.

TRAJECTORIES OF THE CG

The first and most obvious comparison between the different giant swings is the path of the gymnast's CG. Figure 3 shows these paths. The wind-up and the dismount giant follow very similar paths, however, the regular giant follows a different path.

The path of the CG for the Regular Giant swing is oriented vertically. The gymnast is fully extended, from the handstand position to nearly the end of the descent phase. The CG follows almost a circular path for this stage of the giant swing. During the ascent phase, the CG path deviates from this circle and moves closer to the bar, following a flatter path. Near the end of the ascent phase, the CG moves away from the bar and the gymnast finishes in a fully extended handstand.

The flatter path of the CG during the ascent phase is caused by a piking action (Figure 1). This enables the gymnast to compensate for the energy loss due to friction and wind resistance. Acceleration is not necessary in the regular giant swing so this piking action need only be relatively mild.

The wind-up and dismount giants are intended to accelerate the gymnast. They are used to provide maximum energy for the dismount prior to release, consequently, the path followed by the CG in these two giants is different to that of the regular giant. It is a tilted ovular shape (Figure 3).

ANGULAR VELOCITY OF CG

If the gymnast were a rigid body swinging around a fixed pivot point, then his angular velocity would increase as he falls, reaching a peak at the bottom of the swing and then decrease again as the gymnast rises. The curve would have a single peak. However, the gymnast is not a rigid body, in fact, he has control of at least three or four segments of his body. He uses the beat action, previously mentioned, to increase the energy to overcome friction. This beat action causes a two peaked curve as shown in Figure 4a.

Figure 4a is a graph of angular velocity against angular displacement and represents the angular velocity curve for one giant swing. Figure 4b represents the position the gymnast is in, corresponding to the peaks and troughs on the curve in Figure 4a. This example data were from one of the digitized regular giant swings.

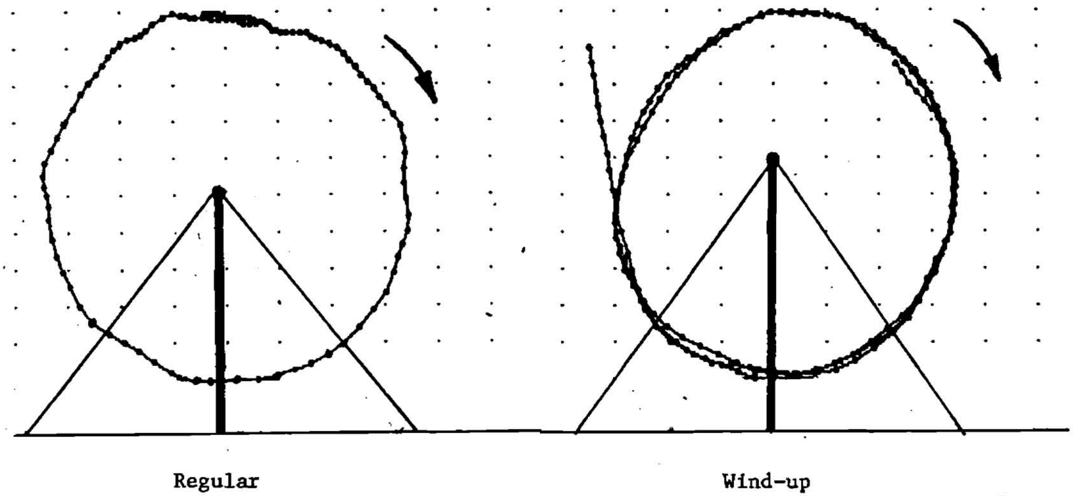
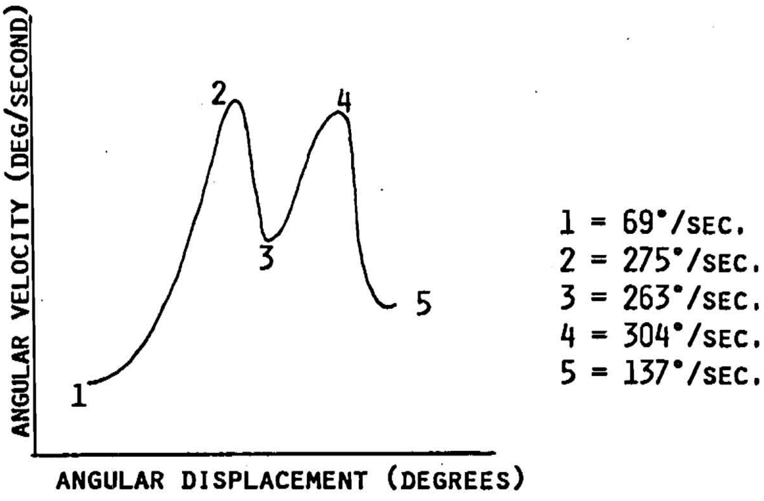
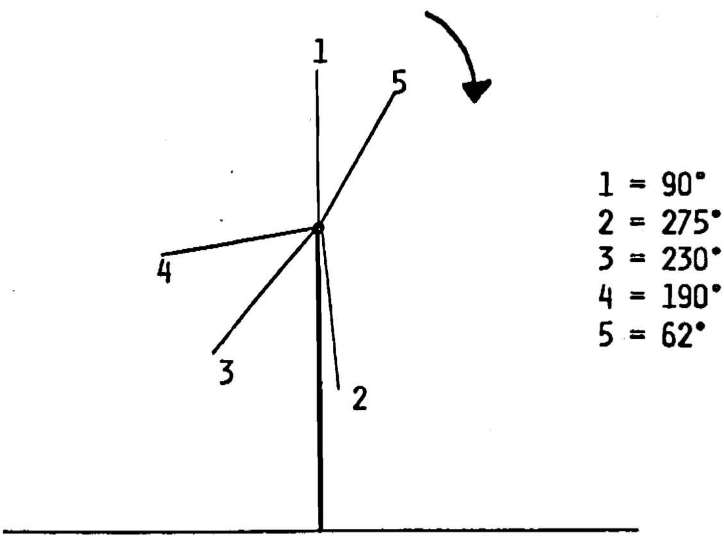


Figure 3. Giant Swing CG Trajectories



a.



b. ANGULAR VELOCITY CHARACTERISTICS

Figure 4. Angular Velocity Characteristics of CG during a Giant Swing

Point 1 in Figure 4 represents the start of the giant swing, in this case from the handstand position. Angular velocity rises as the gymnast falls from the handstand position. Maximum descending angular velocity is reached at Point 2. Here the gymnast is slightly arched and very near the bottom of his swing. However, the gymnast now extends to the straight position and by Point 3 he is fully extended. Here his center of gravity is at its furthest point from the bar. This slows his angular velocity down and we see the trough in Figure 4a, Point 3. Now he pikes at the waist and this shortens the radius from the CG to the bar. This increases his angular velocity, which reaches a peak at Point 4. Now as he approaches the handstand he extends and his angular velocity slows, both due to the effect of gravity and the extension. In this case his slowest angular velocity was not exactly back at the handstand position but just passed it at 62 degrees.

The timing and magnitude of the beat action will determine the size and position of these peaks and troughs in Figure 4a. So the gymnast has partial control over the shape of the angular velocity curve during the giant swing. There should be specific aspects of this curve that point to good or bad technique for the specific giant swing being performed. This, in fact, was the case and some of these technique indicators will now be discussed.

BEAT CHARACTERISTICS BEFORE RELEASE

We will now look at a specific example of the angular velocity characteristics during the dismount giant. Figure 5 shows this example. In Figure 5a, we again see the typical two peaked curve of the giant swing. This is typical of all the three types of giants studied.

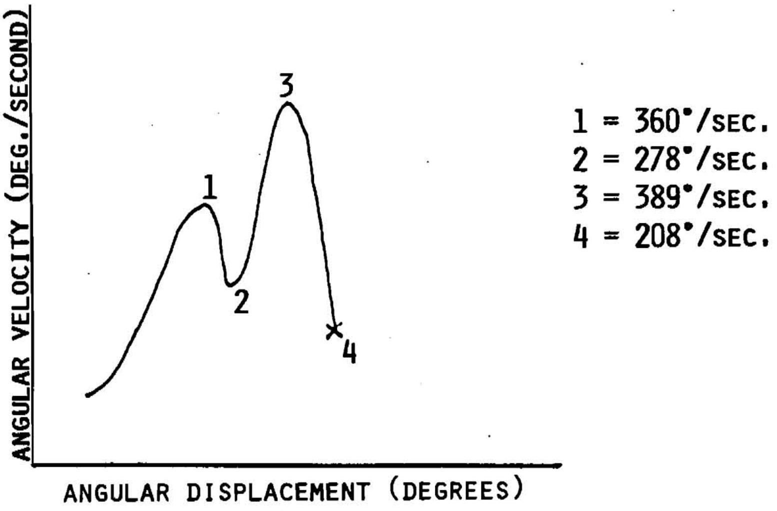
The goal of the beat action, as previously outlined, is to overcome the energy lost by friction and wind resistance. In the wind-up and dismount giants, the beat action, also has another aim and that is not just to maintain angular velocity but, in fact, to increase it. Hence, it is hoped that after the beat action the angular velocity will be higher than before it. So the gymnast of Figure 5 has actually achieved his goal, that is, Point 3 on Figure 5a is higher than Point 1.

Using this method to study the gymnasts dismount giant we have an excellent quantitive measure that allows us to determine whether a specific gymnast has technique errors in his giant swing.

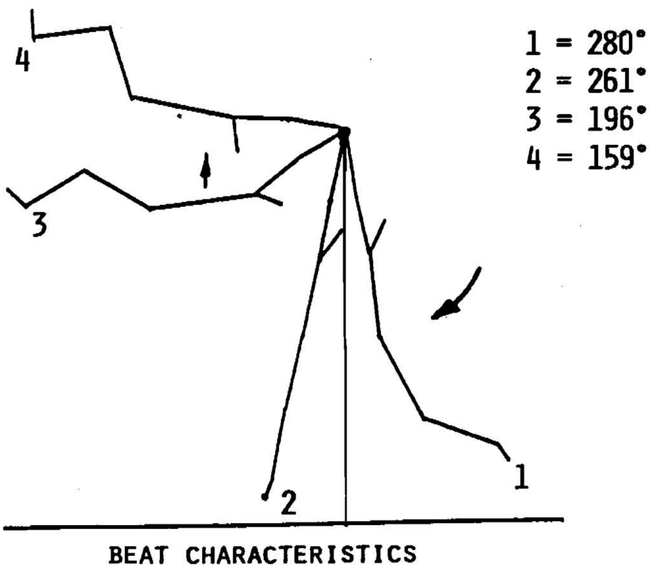
In four of the five cases from the gymnasts studied, the second peak in angular velocity was higher than the first. This implies in all but one case these elite athletes have refined the beat action to make it effective in increasing the angular velocity just prior to release for the dismount.

WIND-UP AND DISMOUNT GIANTS

We will now examine the peak angular velocity within each giant over three giant swings, that is, two wind-up giants and the dismount giant.



a.



b.

Figure 5. Angular Velocity Characteristics of CG the Dismount Giant

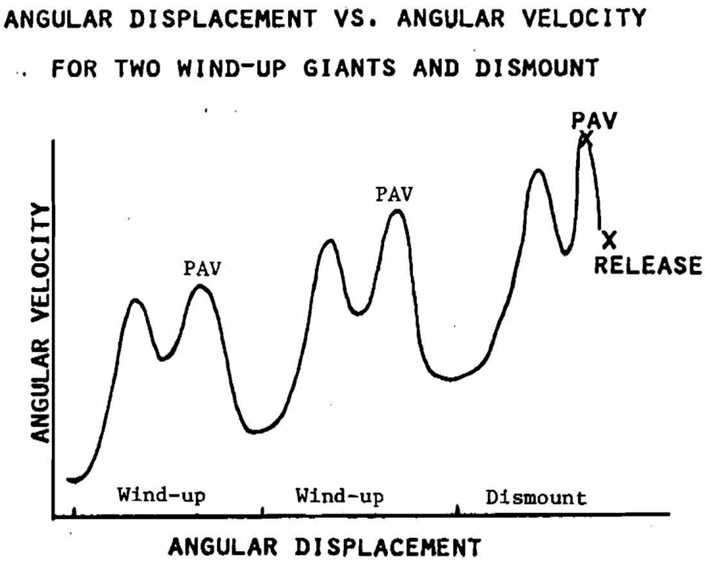


Figure 6. Angular Velocity Characteristics of CG during Two Wind-up and One Dismount Giants

PEAK ANGULAR VELOCITIES (DEGREES/SECOND)

FOR REGULAR AND WIND-UP GIANT SWINGS

SUBJECT	REGULAR	WIND-UP
1	352	357
2	344	359
3	293	336
4	301	344
5	300	319

Table 1. Peak Angular Velocities for Wind-up and Dismount Giant Swings

The idea behind the wind-up giant, as previously stated, is to supply the dismount giant with the highest angular velocity possible, to fascilitate the best initial conditions for the dismount. Figure 6 shows this theory in graphical form, in terms of the angular velocity. Notice how the peak angular velocity (PAV) within a giant swing increases from one giant to the next, culminating in the highest PAV just before release. Each of the five gymnasts examined in this study exhibited this trend, and in every case the PAV of the dismount giant was higher than the PAV in the last wind-up giant. Table 1 shows these results. This suggests that each of these elite gymnasts had achieved their goals of using the wind-up giant to increase angular velocity and to set themselves up appropriately for the dismount.

Young gymnasts often use these wind-up giant swings ineffectively. They may do two or three giants before the dismount but gain nothing from them, stopping each time between giants. Using this method of digitization and CG calculation, gives us a quantitative method to assess the effectiveness of their wind-up giants.

DROP OFF OF ANGULAR VELOCITY

Both Figures 5a and 6 show a PAV just before release followed by a rapid decline in the angular velocity up until the time of release.

This decline of angular velocity is very interesting if we are to study the dynamic release characteristics of the gymnast before the dismount. This is not in the scope of this paper, however, it is of interest to make a few pertinent observations.

The angular velocity must decrease after its peak since gravity is now working against the progression of the CG around the bar, but how much and how rapidly this velocity decreases and how it is partitioned into its respective linear velocities could be the topic of future studies. This study would necessitate investigation of the spring action of the bar itself, the dismount trajectory the gymnast wishes to follow, and his momenta and energy in the interval of time around the release.

SUMMARY AND CONCLUSION

Three indicators of the techniques characteristic of Regular, Wind-up and Dismount giants have been found:

1) Trajectory. Figure 4 shows that the wind-up and dismount giants have a characteristic "titled oval" shape compared to the more vertical alignment of the regular giant's trajectory. This is used to more effectively set up the gymnast for his dismount.

2) Peak Angular Velocity within the giant. Figure 5 shows that the second peak in angular velocity should be higher than the first in order to successfully increase the angular velocity at the end of the wind-up or dismount giant swing.

3) The purpose of Wind-up Giant, is to increase the angular velocity from one giant to the next. Figure 6 illustrates this purpose. There should be a gradual increase in the peak angular velocity from one wind-up giant to the next, culminating in a maximum peak angular velocity in the dismount giant.

These technique indicators can be easily extracted from high speed film of the gymnast. Then they can be used by the coach as a quantitative measure of good or bad technique in the three types of giants studied. Future studies will focus on verifying these findings with a larger subject group including juniors.

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