TWISTING BASICS

>> Nastia Liukin on floor exercise.
This article is the first of a series of articles reviewing gymnastic twisting techniques on each apparatus. The emphasis in this one is on floor exercise. Of course, to be complete, the physics underlying basic flipping and twisting is also included. Flipping and twisting skill basics are usually learned on floor first. These techniques can then be applied to any piece of equipment.

In the continued evolution of gymnastics, one problem we face is the separation of biomechanists and coaches. Most biomechanists are unfamiliar with the small adjustments a gymnast makes during the performance of a skill so it is difficult to apply the laws of physics appropriately. Coaches (and gymnasts) are often not familiar with these laws and continue to teach and perform intuitively. This article is an effort to close that gap.

Skills that include flipping and twisting require more energy to perform than flipping skills alone. We describe the energy of movement as kinetic and split it into translational and rotational components. The translational component comes from the running speed of the athlete. The rotational component is more a function of technique and body shape as the gymnast becomes airborne. These energies are two of four that are traded during the performance of the skill. The others include potential and elastic potential energy and will be ignored for now. If translational energy is converted to rotational energy efficiently, it allows the gymnast to successfully perform more complex tasks.

One of the base skills in tumbling is the flip (or salto). Flipping is defined as rotation around an axis that is oriented in a left-right direction (Figure 1). The axis goes through the center-of-mass (COM) of the gymnast (roughly at the level of the mid lumbar region in a standing individual). The salto can be performed in the tuck, pike, or layout position. As the body position is lengthened, more energy is required to complete the flip. The shape of the body affects its rotational inertia (or moment of inertia – MOI). Thus there is a natural training progression from tuck to layout.

Additional progression of the flip can be accomplished by adding a twisting element. Twisting is defined as rotation around the long axis of the body (Figure 2). This axis can be visualized by drawing a line from the top of the head down through the bottom of the feet. Twist initiation can occur at different times during the flip and impacts the rotational energy of the skill.

**EARLY PHASE TWISTING**
Early phase twisting is defined as long axis twisting that starts prior to the feet leaving the ground. Often, in an effort to generate angular momentum around the long axis of the body, an exaggerated turning of the head,
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shouders, and arms may be observed in the direction of the twist prior to leaving the floor. A paper in the 80’s described the majority of twisting at that time to be accomplished by early initiation (George, 1980). Multiple twisting techniques were executed with up to 90° of rotation prior to leaving the floor. Current gymnastic techniques favor late phase initiation, improving technical execution and efficiency in energy transfer (Yeadon, 1997; Sands et. al. 2008).

LATE PHASE TWISTING
Late phase twisting is defined as long axis twisting that is initiated in the absence of external forces. In other words, the gymnast is no longer on the floor when the twist is started. This can be accomplished by creating asymmetry between the left and right sides of the body during the flip or by using a pike-arch technique. Both result in a transfer of angular momentum from the flipping axis to the twisting axis. This energy transfer doesn’t need to be large. The MOI around the twisting axis is much smaller than the flipping axis. This results in large twisting accelerations from small energy transfers.

TRAINING BACKWARD TWISTING
In order to teach a twist, the gymnast must first be able to perform a layout or open-tuck salto. Late phase twisting can be taught a number of ways. One way to promote asymmetry is to have the gymnast perform a back salto and anteriorly raise one arm straight overhead just prior to landing the skill. This promotes off-axis rotation (twist) in the direction opposite the raised arm and will teach the gymnast that they can control the rate of twist through the speed of their arm raise. The other important lesson is that “twist takes away from flip”. The flipping energy (and therefore speed) will decrease as they raise their arm. They will have to supply more energy to the skill to be successful and land on their feet. The next step in the progression is to start to initiate the twist sooner. Since a gymnast performing a layout salto drops both arms just after take-off to facilitate the flip, it is usually a simple step to have them drop just one arm to initiate the twist. It is important that the gymnast understand that the arm is not dropped until they are inverted and that they will twist in the direction of the dropping arm.

The final step is what to do with the remaining arm (the one that is still overhead). One approach is to have the gymnast land in the one-arm-up and one-down position and then drop the second arm. This one-two method seems to work with most and eventually results in earlier initiation with smooth arm movement, but still within the confines of late phase twisting.

Progression to multiple twisting back saltos requires additional off-axis asymmetry by having the gymnast bias their take-off with one arm reaching higher than the other (the higher arm is opposite the direction of twist). This off-axis take-off promotes a gyro effect (or nutation) and transfers energy efficiently from one axis to another. It also decreases the MOI along the flipping axis and decreases the energy required to complete the skill.

An unusual example: I had the challenge of teaching a double twisting back layout salto to a girl who had a lot of trouble progressing past 1½ twists. Part of it was her body proportion; longer bodies tend to twist better since they can typically leave the floor with more rotational energy. She was not very tall, but was very strong. She found that she could complete the final ½ of the twist by raising her arms (essentially leaving mass behind during the last phase of the flip). This allowed her to use her hips (arch-to-pike) to complete the final twist while still having enough energy to concurrently complete the flip. I have no doubt that over time she will successfully perform the skill with what most of us consider normal mechanics. But, in the short term, she is practicing the skill and gaining more and more kinesthetic awareness every day.

TRAINING FORWARD TWISTING
The direction of front twisting is often confusing to the gymnast and some coaches when it is learned as an extension of the round-off. A round-off that leads with the left hand is actually a right twist. This is determined by the backward direction of right shoulder as the round-off progresses. If the gymnast learns to twist in a forward direction utilizing a “contact” twist (or early phase twisting), they typically try to follow the “perceived” twist direction of the round-off and go the wrong direction. There are differences of opinion regarding whether the twist direction of the round-off should match the airborne twist, but all agree that the direction of the front twist...
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should match that of the back twist. If this direction is opposite to the back twist, the coach is faced with two options; (1) change the direction of the round-off or (2) change the direction of the backward twist. Both are viable options, but neither will be successful with all gymnasts.

There are advantages to twisting airborne skills in a direction opposite the round-off. One is that it requires the gymnast square the take-off and use the more efficient late phase twist initiation technique described earlier. This can be seen in the Kazamatsu vault and more recently on a round-off full beam mount performed by Natumi Sasada of Japan. The second advantage is again squaring the gymnast when tumbling out of backward 1/2, 1 1/2, or 2 1/2 twisting skills. This opposite direction technique may only be beneficial to more advanced gymnasts, but is probably worth any additional training time and effort. (McCharles, 1996)

To avoid confusion, many coaches promote training the front twist as a late phase twist and use a pike-open approach. The benefits should be obvious. First, the direction of the round-off no longer impacts the performance of the skill and second, efficiency is improved in the transfer of energy from the flipping axis to the twisting axis. Many good full twisting front layouts begin with a slightly closed hip angle to promote late phase twisting. Those that are taught to leave the floor in an open hip position need to use an asymmetric arm technique to initiate the twist. Flip speed is easily compromised and often results in incomplete rotation. When using this technique, the “overhead” take-off arm is in the direction of the twist.

SOME USEFUL DRILLS

The following drills may be useful in promoting the transfer of energy from the flipping axis to the twisting axis during late phase twisting.

- Forward roll pike-up to handstand drills with initiation of a piroette just prior to complete hip extension.
- Front head-spring (pike) 1/2 turns to a prone push-up position to facilitate and reinforce twist timing and direction. This can be done downhill on a wedge mat.
- Front pike salto pike-open drills to initiate front twisting and efficient energy transfer. Recall those who teach arched layout take-offs are often faced with early phase twisting that has reduced flipping power.
- Back extension roll – blind change drills with a focus on initiating the reverse piroette just prior to full shoulder opening. This actually produces a frontal plane asymmetry that promotes energy transfer to long axis twisting.

SUMMARY

There are many ways to teach a twisting skill. The concepts described in this article are meant to provide guidelines rooted in physics. Every gymnast is a little different. Body size and composition impact the application of these techniques. Larger bodies have larger inertial moments and therefore require more energy to flip. Once started, however, that energy can be transferred from one axis to another easily. Unless we strive to teach a single body type, then an understanding of the basic principles of movement are required to be successful coaches and teachers.

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REFERENCES


