

## LEARNING HOW TO TWIST FAST

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Progressions are presented for learning aerial twisting forward single and double somersaults with  $1\frac{1}{2}$  twists and backward single and double somersaults with one twist. These progressions are based on the results of computer simulations and make a single change in technique from one stage to the next. They are best introduced on trampoline and then transferred to the gymnastics apparatus. It is possible to make rapid progress in learning complex skills in relative safety provided that consistency is achieved at each stage before progressing to the next. The advantage of using aerial twist is that it makes takeoff and landing much easier and safer.

**KEYWORDS:** twist, somersault, simulation, model, coaching, progressions

### INTRODUCTION

The orientation of a gymnast during a twisting somersault may be described by the angles of somersault, tilt and twist (Figure 1). Somersault rotation takes place around a horizontal axis through the mass centre while twist rotation is around an axis fixed in the body. The direction of somersault relative to the fixed axis does not change during a twisting somersault and neither does the direction of twist (left or right) relative to the longitudinal body axis. Tilt is the angle between the twist axis of the body and the vertical somersault plane.

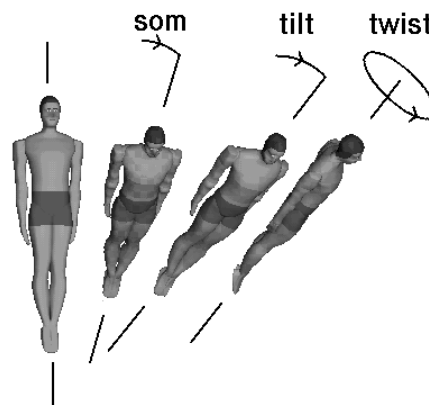


Figure 1. Angles of somersault, tilt and twist

### ANGULAR MOMENTUM

During the flight phase the total angular momentum about the mass centre will remain constant. Suppose for simplicity that no twist is taken from the gymnastics apparatus so that at takeoff the only rotation is the somersault about a horizontal axis through the mass centre. The angular momentum may be represented by the horizontal vector  $\mathbf{h}$  in Figure 2. At takeoff the twist axis is perpendicular to  $\mathbf{h}$  and there is no twist. If the twist axis becomes tilted out of the vertical somersault plane later in the somersault there will be a component of angular momentum in the direction of the twist axis and the gymnast will twist. If the tilt angle is greater, the twist component of angular momentum will be greater and the twist will be faster.

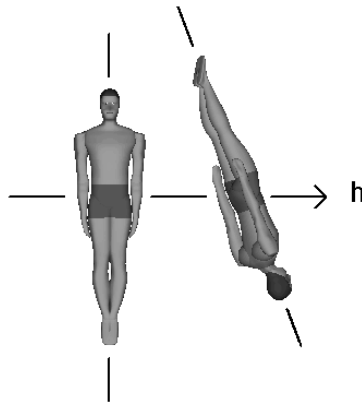


Figure 2. There is a component of the angular momentum  $h$  along the twist axis when the body is tilted out of the vertical somersault plane.

### RIGID BODY MOTIONS

To understand the mechanics of a multi-link system performing somersaults with twist, it is helpful to look at the rotational motion of a rigid body. There are only two general types of motion that a rigid body can exhibit (Yeadon, 1993a). The first of these is the **wobbling somersault** in which the body somersaults about a horizontal axis but also has an oscillating motion in which it twists one way and then the other (Figure 3). During this motion the body also tilts first one way and then the other so that the head is to one side of the feet and then later to the other (see the first and last images in Figure 3). Thus adopting a piked position may not only slow the twist in a movement, it may also effectively stop the twist.



Figure 3. During a wobbling somersault the twist oscillates left then right.

The second type of motion is the **twisting somersault** in which the twist is always in the same direction (Figure 4). During this motion the body is always tilted in the same direction away from the somersault plane. This tilt varies with the twist and is smallest for an even number of quarter twists (images 1, 5, 9 of Figure 4) and greatest for an odd number of quarter twists (images 3 and 7 of Figure 4). This variation in the tilt angle is known as *nutaton* from the theory of spinning tops (Syngé and Griffith, 1959) and is important for the understanding of how aerial twist is produced (Yeadon, 1993c). In the twisting somersault shown in Figure 4 the variation in the tilt angle is quite large since the arms held wide.

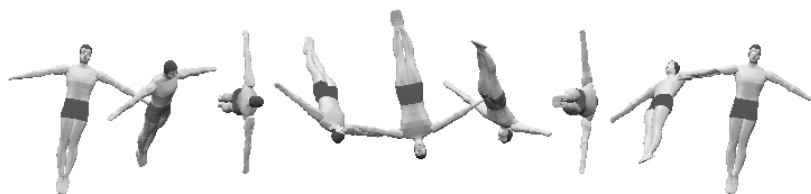


Figure 4. During a twisting somersault the twist continues in one direction.

## CONTACT TWIST

Angular momentum is built up while the body is in contact with the gymnastics apparatus so that it is somersaulting at takeoff. Twist may be initiated in a similar way by turning the arms and trunk in the direction of the twist while the feet are in contact with the takeoff surface. During the aerial phase of a contact twist the body becomes tilted away from the vertical after half a somersault and then automatically becomes untilted as the somersault is completed (Yeadon, 1993b). The disadvantage of contact twist is that the gymnast will be twisting when landing and this could lead to a greater risk of ankle injuries. In high bar dismounts there is even more of a potential problem since only  $\frac{3}{4}$  or  $1\frac{3}{4}$  somersaults are completed and the body is likely to still be tilted on landing.

## AERIAL TWIST

The way in which a cat rights itself by producing a half twist in mid-air after being dropped in an inverted position has been studied for more than a century (Marey, 1894; McDonald, 1960). Some coaches have thought that this is a major mechanism that gymnasts use to produce twist (Biesterfeldt, 1974). The twist is produced by using a hula-hoop circling movement of the hips during the aerial phase. If the initial angular momentum is zero it must remain so during flight and so the angular momentum associated with the hip circling produces a twisting of the whole body in the opposite direction (Kane and Scher, 1969). A simulation of this movement is shown in Figure 5 in which the hips circle to the right producing a twist to the left. The body moves from a forward flexed position through a side arch over the right hip, into a back arch, through a side arch over the left hip and ends in a forward flexed position again, having completed a half twist. A skilled trampolinist can produce a full twist using two cycles of such a movement while airborne.

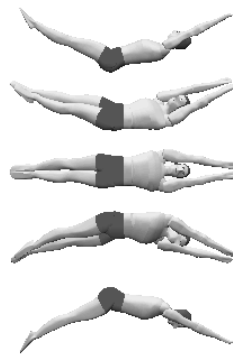


Figure 5. Computer simulation of an aerial half twist using the “hula” or “cat” technique.

It is evident that gymnasts do not use this hula technique to produce multiple twists during the aerial phase of a somersault since the body typically remains straight during the twist. If somersault is present then any technique that tilts the body away from the somersault plane will result in twist in order to maintain constant angular momentum (Frolich, 1980). If one arm is raised laterally in a plain jump while lowering the other, the whole body will tilt in order to maintain zero angular momentum (upper sequence of Figure 6). If the same arm movements are made during a somersault, a similar amount of tilt results and the body automatically twists in order to maintain constant angular momentum (Yeadon, 1993a).

## CREATING TILT

Tilt can be produced after takeoff using asymmetrical movements of the arms. The upper sequence of Figure 6 shows that when these lateral arm movements are made during a jump the body tilts in the opposite direction to maintain zero angular momentum. That is, the rotation of the arms in the anti-clockwise direction must be counteracted by an equivalent rotation of the rest of the body in the clockwise direction. When the same arm movements are made during a somersault this tilt results in twist as shown in the lower sequence.

Lowering the right arm and raising the left arm will cause the body to tilt to the left. This tilt will cause the body to twist to the left during a forward somersault. Similarly lowering the left arm will cause the gymnast to twist to the right during a forward somersault.

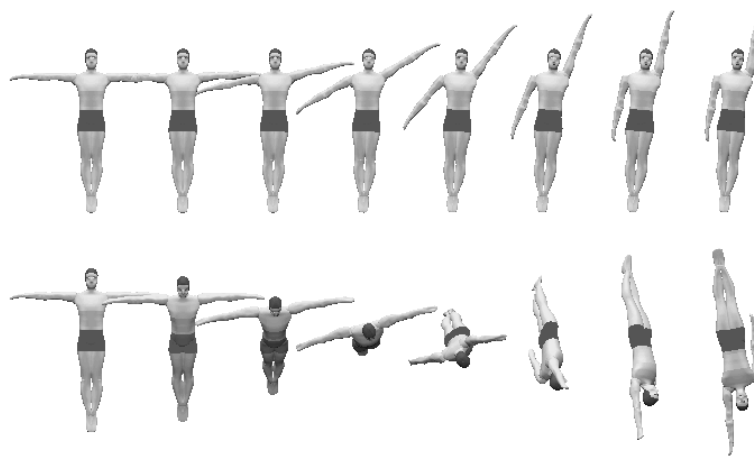


Figure 6. Asymmetrical arm movement produces tilt (a) when there is no somersault and (b) when the body is somersaulting forwards.

Any movement in which left-right symmetry is not maintained is likely to produce some twist. In the simulation shown in Figure 7 the body makes a partial hula movement while extending from a piked to a straight position. In a plain jump this hula movement with wide arms produces tilt while the body is in a side arch configuration (Yeadon and Atha, 1985). The upper sequence shows that such movements also produce a small amount of twist when there is no somersault. When somersault is present the hip movement produces tilt which results in a rapid twist as shown in the lower sequence (Figure 7). The advantage of this technique is that the arms may be held symmetrically and this gives a cleaner look to the movement. For a twist to the left the body flexes over the right hip as the gymnast extends from the piked position. The hip action is very similar to performing a quarter of a hula-hoop movement while extending the body. This action may be rehearsed with the gymnast standing on the floor before it is attempted during a forward somersault.

It is fortuitous that the hula movement that produces a twist to the left in a jump also produces tilt which will result in a twist to the left in a forward somersault. During the takeoff for a forward somersault from the floor, the body flexes forwards at the hips so that initially it is piked which is an appropriate starting position for this twisting technique.

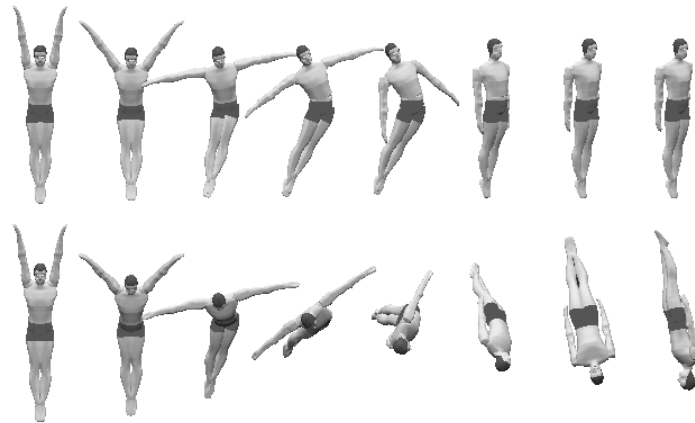


Figure 7. Production of tilt using asymmetrical hip movement (a) when there is no somersault and (b) when the body is somersaulting forwards.

Aerial twist is a result of producing tilt after takeoff. The advantage of using aerial twist is that the twist stops when the tilt is removed. Therefore, unlike landing from contact twist, the gymnast is more likely to have stopped twisting and to land squarely.

### LEARNING FORWARD SOMERSAULTS WITH 1½ TWISTS

The following progression may be used to learn a forward somersault with 1½ twists and a double forward somersault with 1½ twists in the second somersault. The progression is based on using asymmetrical hip movement to produce the tilt. This technique is most appropriate for the twisting double somersault since the twist has to be initiated in the airborne phase of the skill. The progression starts with the gymnast performing a non-twisting somersault with the body initially slightly flexed at the hips (Figure 8). During the forward somersault the gymnast should concentrate on keeping the arms spread wide. The upper sequence shows the body configurations without the somersault. All sequences shown in this progression are based on computer simulations produced using the model of Yeadon, Atha and Hales (1990).

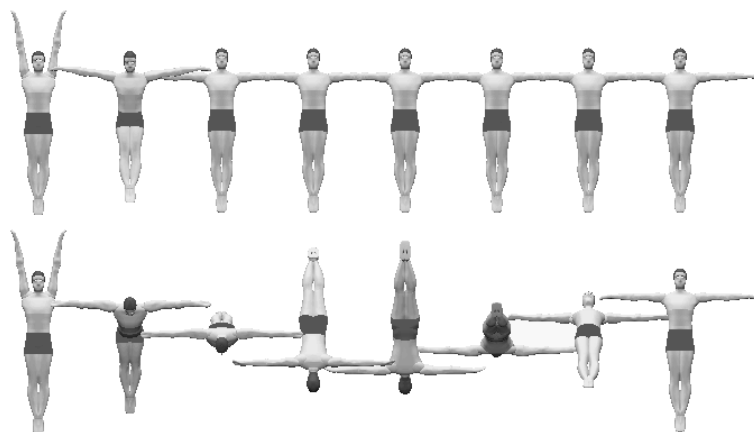


Figure 8. A forward somersault from a shallow piked position with wide arms.

The next step is for the gymnast to perform the forward somersault with a half twist (Figure 9). The body flexes over the right hip soon after takeoff. Again the gymnast should concentrate on maintaining the arms in a wide spread position. In order for the gymnast to stop the twist the tilt created by the asymmetrical hip movement must be removed. This may be achieved by again using asymmetrical hip movement (Figure 9). This skill should be practised until a half twist can be done with arms held wide.

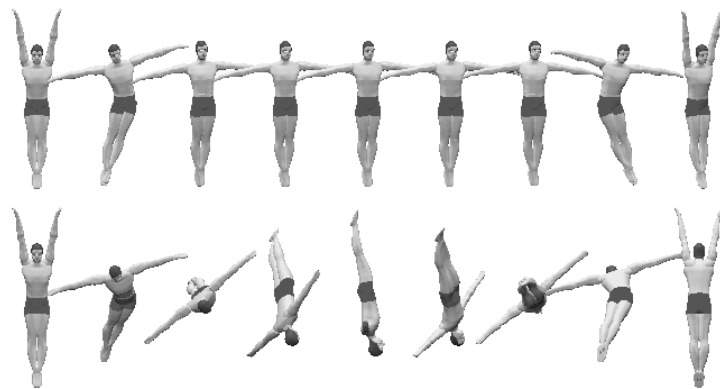


Figure 9. Using asymmetrical hip movement to produce a wide arm half twist in a forward somersault.

Next the gymnast should progress to a forward somersault with  $1\frac{1}{2}$  twists. The twist should be started in exactly the same way as the half twist and then the arms should be moved to the sides so that  $1\frac{1}{2}$  twists are produced (Figure 10). The arms should be held wide during the hip movement in order to produce sufficient tilt. Once the twist has started, lowering the arms to the sides will reduce the moment of inertia about the twist axis. To maintain constant angular momentum there must be a corresponding increase in the gymnast's twist rate. It is therefore beneficial to return to the half twist skill to and ensure that it is performed with arms held wide. The twist is again stopped by removing the tilt using asymmetrical hip movement (Figure 10).

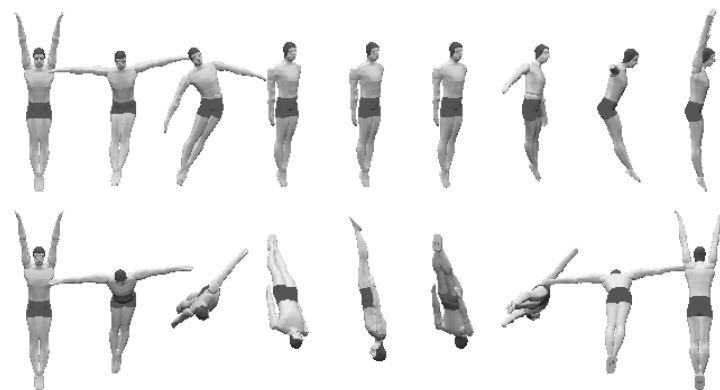


Figure 10. Using asymmetrical hip movement to produce  $1\frac{1}{2}$  twists in a somersault.

The next step for producing  $1\frac{1}{2}$  twists in a double somersault is to perform a half twist in a double somersault. The same technique used in the half twisting single somersault may be used to produce a wide arm twist in a double somersault (Figure 11). The body is flexed over the right hip as extension is made from the piked position. With more hip flexion the tilt is greater and the arms can be held wider. The half twist in the second somersault should be performed with wide arms and a straight body (Figure 11).

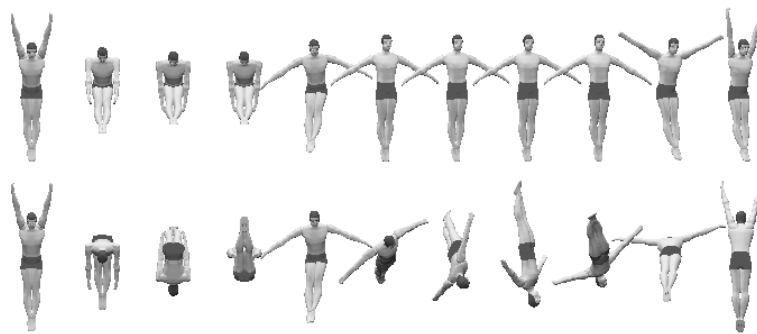


Figure 11. A double somersault with a wide arm half twist in the second somersault.

The final stage is to perform the double somersault with  $1\frac{1}{2}$  twists. To do this the arms must be brought close to the body once the twist has been initiated. The arms should be wide when the twist is initiated and then brought close to the body after the twist has started (Figure 12). It is important to remember that sufficient somersault is needed at takeoff to allow the body to be fully extended during the twist. In order to remove the tilt both asymmetrical hip and arm movements are used (Figure 12). Typically the right arm is abducted away from the body after  $1\frac{1}{4}$  twists and subsequently the left arm is also abducted. Common errors when first attempting this skill are to under-rotate the somersault, to start the twist too early, and to fail to use a wide arm position during the asymmetrical hip movement. In order to avoid such tendencies the wide arm double somersault with a half twist should be learned correctly and practised sufficiently before attempting the  $1\frac{1}{2}$  twists. Once the gymnast becomes familiar with the movement, the arms will not need to be spread so wide for the initiation of the twist.

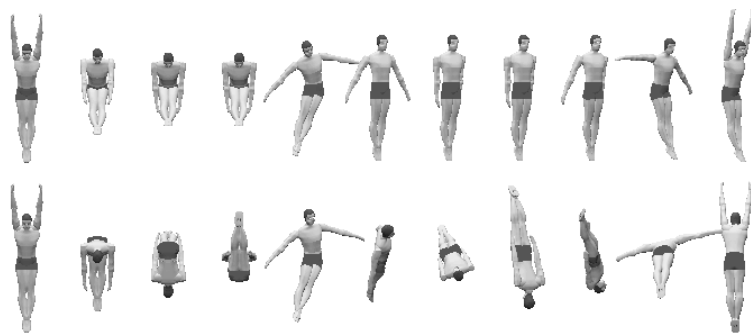


Figure 12. A double somersault with  $1\frac{1}{2}$  twists in the second somersault.

## LEARNING BACKWARD SOMERSAULTS WITH ONE TWIST

This progression is based on using asymmetrical arm movements to produce the tilt which leads to aerial twist. The initial movement comprises a straight backward somersault in which the arms are lowered from an overhead position and then held wide (Figure 13). It is important that the arms move from an overhead position to the sides. Any tendency to lower the arms down the front of the body parallel to the sagittal plane should be corrected. The upper sequence of Figure 13 shows the arm movement without the somersault.

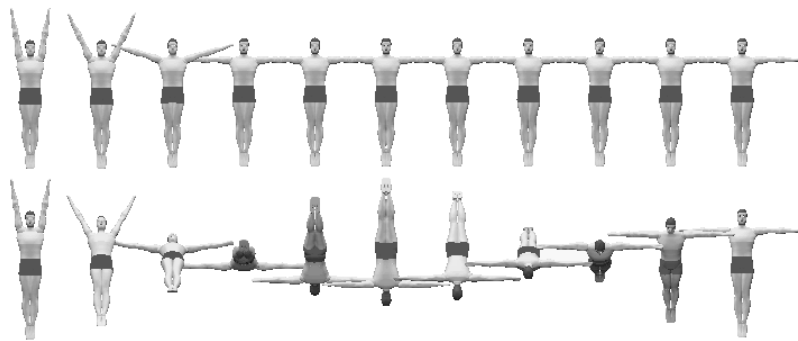


Figure 13. A backward layout somersault with wide arms.

The next movement starts in exactly the same way but the left arm is lowered further than the right arm so as to produce the tilt required for a twist to the left. This results in a wide arm backward somersault with an aerial half twist to the left in the second half of the somersault (Figure 14). It is important that the wide arm position is maintained throughout the movement. This ensures that the gymnast must produce sufficient tilt in order to achieve a half twist with wide arms. Failure to maintain a wide arm configuration may lead to difficulties in producing sufficient twist in the next stage. The amount of somersault rotation completed will be similar to that of the non-twisting somersault.

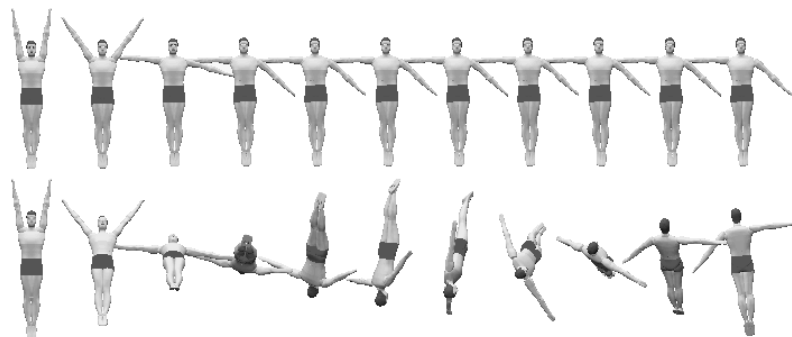


Figure 14. A backward somersault with half twist using wide asymmetrical arms.



Once a half twist with wide arms can be performed consistently it is a relatively simple matter to produce a full twist by bringing the arms close to the body once the twist has started (Figure 15). There will be a tendency to over-somersault this skill since the arms are lower than in the previous two movements. This reduces the moment of inertia about a transverse axis and leads to a faster somersault. The effect of this over-rotation can be counteracted to some extent by raising the arms in front of the body on landing. Although this method does produce a backward somersault with one twist, most of the twist occurs late in the movement and the gymnast cannot see the landing area throughout the skill.

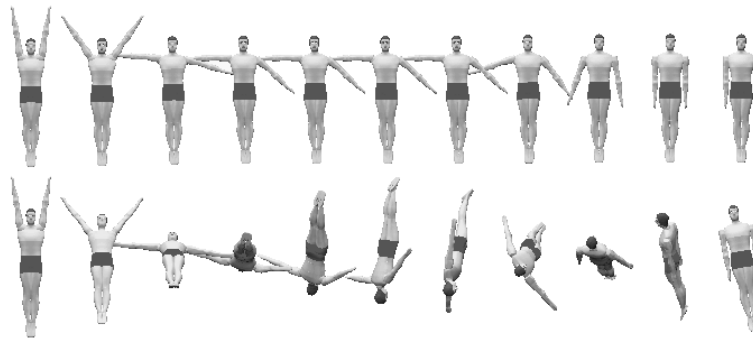


Figure 15. A backward somersault with one twist with a wide asymmetrical arm start.

A more traditional looking full twist may be produced by first lowering the left arm and then the right (Figure 16). The tilt is removed by first raising the right arm and then the left near the end of the movement. In the upper sequence of Figure 16 it can be seen that in a plain jump the tilt disappears as soon as the arms reach a symmetrical position. In the twisting somersault shown in the lower sequence the situation is different since the right arm is lowered at around the quarter twist position and this changes the somersault angle slightly rather than the tilt angle. The phasing of the twist in this movement allows the gymnast to view the landing area throughout the somersault. Since the twist stops once the tilt has been removed, a safe and stable landing is possible. This technique is useful for learning somersault dismounts with one twist from the high bar.

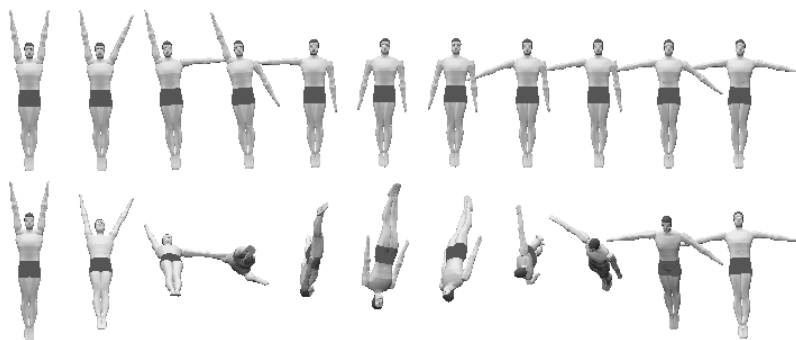


Figure 16. A backward somersault with one twist using asymmetrical arms.

Introducing twist into a double backward somersault may be done in much the same way. Note that a straight double somersault is not as simple as it may look (Figure 17). If a rigid body is somersaulting about its intermediate principal moment of inertia the motion is unstable in the sense that twist will build up exponentially until the body completes a half twist (Hinrichs, 1978; Marion, 1965). In practice this will pose a potential problem for somersaults about a lateral axis when the body is held straight. Yeadon and Mikulcik (1996) showed that the build-up of twist may be prevented by the gymnast making in-flight corrections using small asymmetrical arm movements.

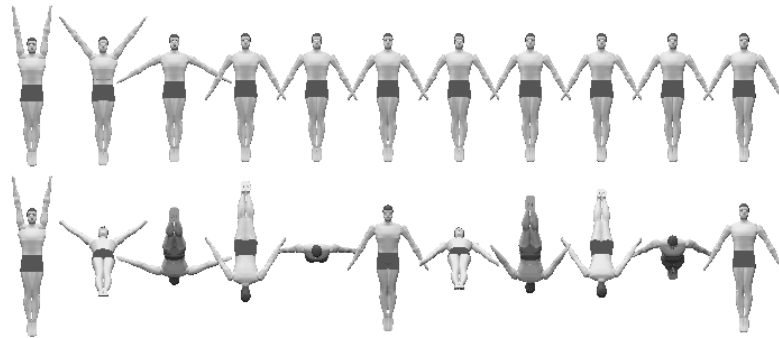


Figure 17. A straight double backward somersault.

The build-up of twist can be used to good effect to produce an aerial twist using only a small asymmetry in the arm positions. Figure 18 depicts a theoretical simulation of a double somersault with one twist in the last  $1\frac{1}{4}$  somersaults. During the first three quarters of a somersault the arms are spread wide but with a small asymmetry. This leads to a slow build-up of tilt and twist during the first somersault. The twist is accelerated by adducting both arms towards the end of the first somersault. As one revolution of twist nears completion, first the right arm is abducted and then the left arm in order to remove the tilt and stop the twist. Since this asymmetrical arm movement for stopping the twist comprises exactly the same technique as for preventing the build-up of twist in a straight somersault it is likely that learning this type of control in a twisting somersault is carried over into the control of non-twisting somersaults and vice versa.

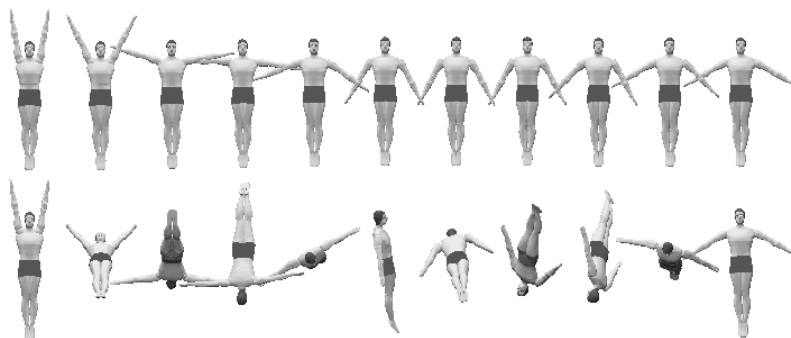


Figure 18. A straight double backward somersault with one twist in the second somersault.

A straight double somersault with two twists may be produced in the same way by using slight more arm asymmetry in the first somersault and adducting the arms close to the body (Figure 19).

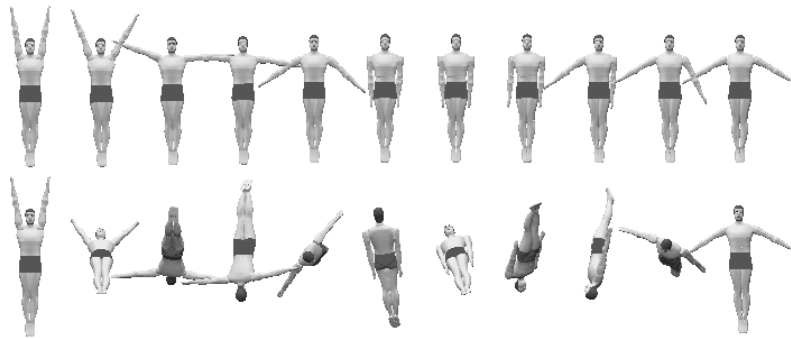


Figure 19. A straight double backward somersault with two twists in the second somersault.

## CONCLUSION

Methods for producing aerial twist in somersaults using asymmetrical movements of the arms and hips have been described. These techniques are most easily introduced on the trampoline and should then be transferred to the floor or apparatus dismounts. The advantages of the progressions are that they allow rapid progress to be made with safety since each step in a sequence changes just one element at a time.

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