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# APPLICATION OF SIMULATION TO FREESTYLE AERIAL SKIING

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The aim of this study was to use a computer simulation model of aerial movement to investigate the ability of asymmetrical arm movements to initiate twist in the flight phase of a triple layout somersault in the aerials event of freestyle skiing. Three arm movements were analysed resulting in triple somersaults with four and five twists together with lead up movements with one twist less. It is concluded that four twists can be initiated during flight using two phases of asymmetrical arm movement and that the production of five twists requires three phases of asymmetrical arm movement.

**KEY WORDS:** simulation, twisting somersault, freestyle skiing

## INTRODUCTION:

In the aerials event of freestyle skiing competitors gain speed while skiing down an incline and then enter a curved takeoff "kicker" which provides vertical velocity and angular momentum for the flight phase which lasts for around 2.6 seconds. During this time the aerialist completes three somersaults in an extended configuration with up to five twists. Previous research on the aerials event has shown that competitors can initiate the twist after takeoff using asymmetrical arm movements (Yeadon, 1989). The following question was posed by a national coach: "How can five twists be produced in a triple somersault using asymmetrical arm movements after takeoff?" This study investigated this question using a computer simulation model of aerial movement (Yeadon et al., 1990).

## METHOD:

**Model:** An 11-segment computer simulation model of aerial movement was customised to a freestyle skiing competitor using anthropometric measurements to obtain segmental inertia parameters. Measurements of skis, boots and helmet were used to adjust the inertia parameters.

**Simulations:** Three types of asymmetrical sequential arm movements were investigated for the ability to produce twist in a triple somersault. An empirical process was used in the search for optimum techniques employing manual adjustments to the timing of arm movements with a constraint of a minimum time of 0.25 s for a single arm movement. In keeping with the expectations of competitive skills the arms were extended as each somersault was completed to "show" the completion of each twisting phase. Additionally the twist in the third somersault was constrained to be no more than one revolution in order to allow room for adjustments prior to landing. The head positions in the graphical output were adjusted so that the head looked down when the head was above the feet and the head looked back when upside down. This head orientation enables a continuous view of the landing area.

## RESULTS:

The first arm sequence comprised a lowering of the left arm to the side followed by a lowering of the right arm to the front (Figure 1). The lowering of the left arm produced a $4^o$ tilt of the body away from the vertical somersault plane and initiated the twist in the triple somersault. The movement of the right arm was timed to occur at around the quarter twist position so that the tilt increased further to $8^o$. This allowed the completion of one twist in the

first somersault, two twists in the second somersault, and one twist in the third somersault. Such phasing of the twist gives rise to the term “full – double full – full” identifying this skill (Figure 2).

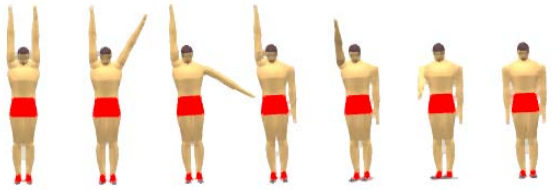

**Figure 1: Left arm lowered to the side followed by right arm lowered to the front.**

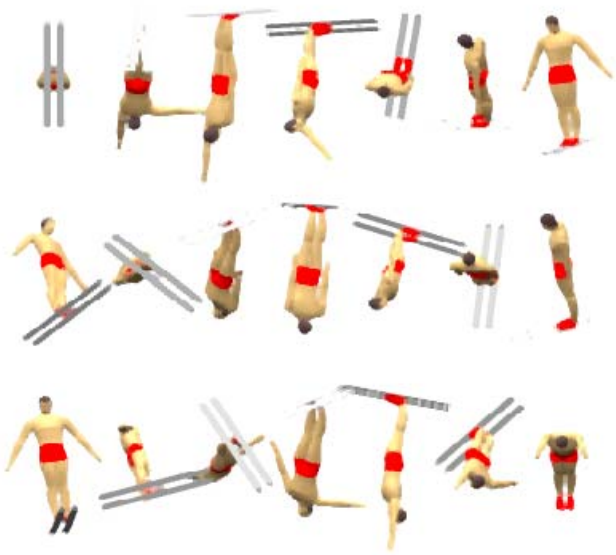

**Figure 2: A “full – double full – full” produced using the arm sequence depicted in Figure 1.**

The second arm sequence comprised a lowering of the left arm to the side followed by a lowering of the right arm to the side (Figure 3). The lowering of the left arm produced a $4^{o}$ tilt of the body away from the vertical somersault plane and initiated the twist in the triple somersault. The movement of the right arm was timed to occur at around the half twist position so that the tilt increased further to $9^{o}$. This allowed the completion of a “full – double full – full” generally similar to that shown in Figure 2.

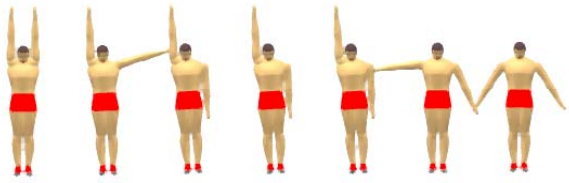

**Figure 3: Left arm lowered to the side followed by right arm lowered to the side.**

The third arm sequence comprised a lowering of the right arm across the body, followed by a double arm switch, and finally a lowering of the right arm down the front (Figure 4). The initial movement of the right arm resulted in little tilt which increased to $9^{o}$ with the double arm switch and increased further to $12^{o}$ with the final lowering of the right arm to the front around the quarter twist position. This was sufficient to allow the completion of three twists in the second somersault resulting in a “full – triple full – full” (Figure 5).

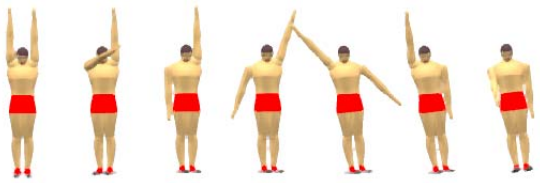

**Figure 4: Arm action in the third simulation: right arm lowered across the body to the side followed by double arm reversal and right arm lowered to the front.**

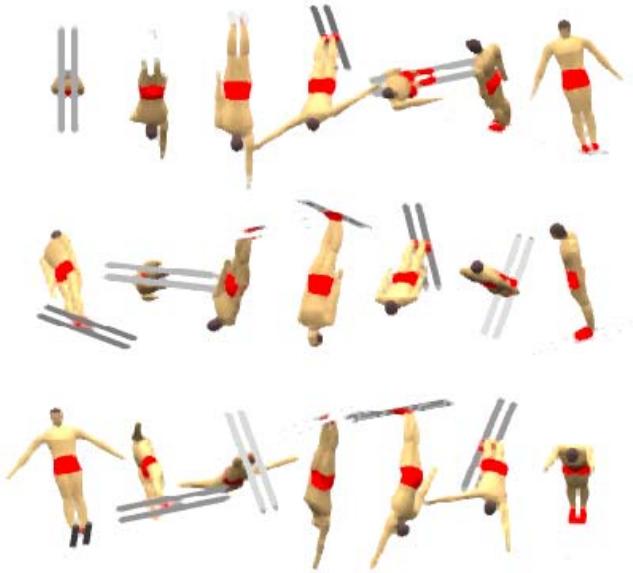

**Figure 5: A "full – triple full – full" produced using the arm sequence depicted in Figure 4.**

A lead up skill for this third simulation was produced using the same sequence of arm movements to initiate the tilt and twist but using a more abducted arm position in the second somersault so as to obtain two twists rather than three. This resulted in a "full – double full – full" with wide arms (Figure 6). The advantage of practising such a lead up skill before attempting the five twists is that it allows a gradual approach in the learning process in which shortcomings can be adjusted by changing the arm position. The amount that the arms can be abducted whilst twisting also gives a measure of the twist potential.

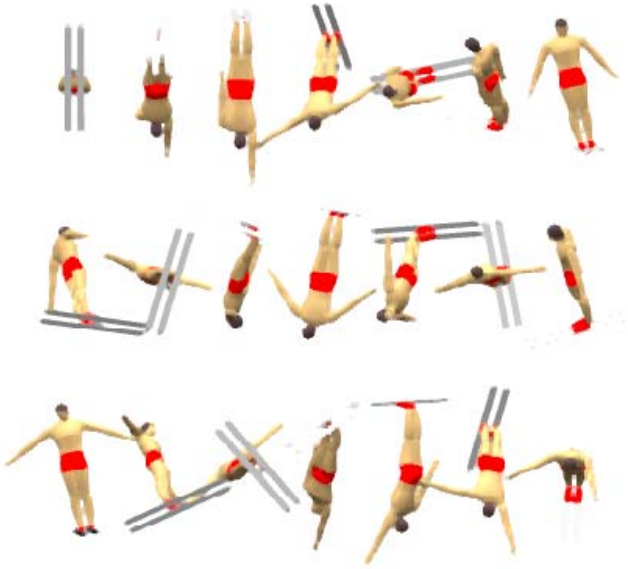

**Figure 6: A "full – double full – full" lead up skill using the same arm sequence as in Figure 5.**

## DISCUSSION:

Three arm sequences were investigated for their ability to produce twist in the airborne phase of triple somersaults in freestyle skiing. Sequences comprising the lowering of one arm followed by the lowering of the other were capable of producing four twists but not five. In order to produce five twists a more complex arm sequence was required involving three phases of arm movement. Although the results are based on a single set of inertia parameters there is sufficient flexibility in the arm positions used in the simulations to accommodate different inertia sets and produce similar outcomes.

It might be thought that the production of aerial twist while wearing skis and boots is made more difficult because the moment of inertia about the twist axis is larger due to the skis and less twist will occur in a somersault. While the moment of inertia about the twist axis is larger, the moment of inertia about the tilt axis is larger still. As a consequence the number of twists per somersault for a tilt angle of $8^o$ is 2.2 compared to 2.0 without skiing equipment and so for a given tilt angle there is an advantage to twisting with ski boots and skis. On the other hand the larger moment of inertia about the tilt axis results in a tilt angle of only $4^o$ when an arm is moved through $180^o$ compared to $8^o$ when there is no ski equipment as in gymnastics dismounts. Thus the difficulty in producing twist in freestyle skiing is really a difficulty in producing tilt. The use of skis and boots with less mass would provide an advantage for creating aerial twist as would gloves with increased mass.

## CONCLUSION:

It is theoretically possible to initiate five twists in the aerial phase of a triple somersault in freestyle skiing using a sequence of three asymmetrical arm movements.

### REFERENCES:

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