# JUMPING STRATEGIES IN A VOLLEYBALL AND A BALLET SPECIFIC JUMP

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## INTRODUCTION

The performance of a maximal vertical jump from a static preparatory position (SQJ) or starting with a counter movement (CMJ) implies transformation of rotation about the hip, knee and ankle joints to a maximal translatory movement. Different strategies have been proposed for this transformation. Hudson argued (1986) that the strategy of a skilled jumper will be a simultaneous rotation of joints in order to support and push the heavy weight of the upper body and to increase the importance of accuracy. While Bobbert & van Ingen Schenau (1988) argued that the optimal strategy must be sequential because of the anatomical and the geometrical constraints. In sport and dance events vertical jumps are performed with specific technical demands. The purpose of this study was to analyse jumping strategies in a volleyball and ballet specific maximal vertical jump. The hypothesis was that the technical demands of the jumps would preset the strategy.

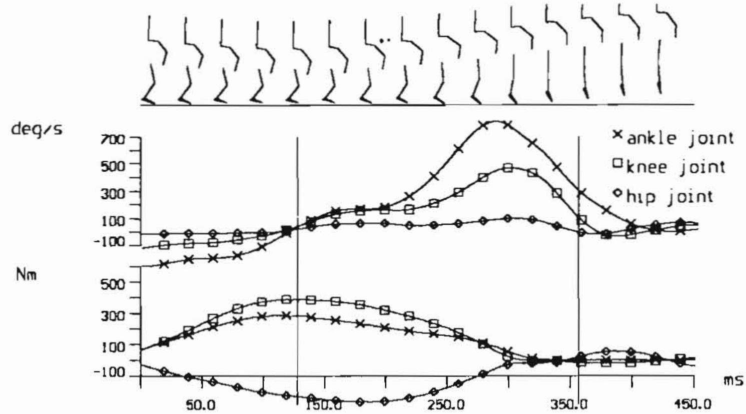
## METHODS

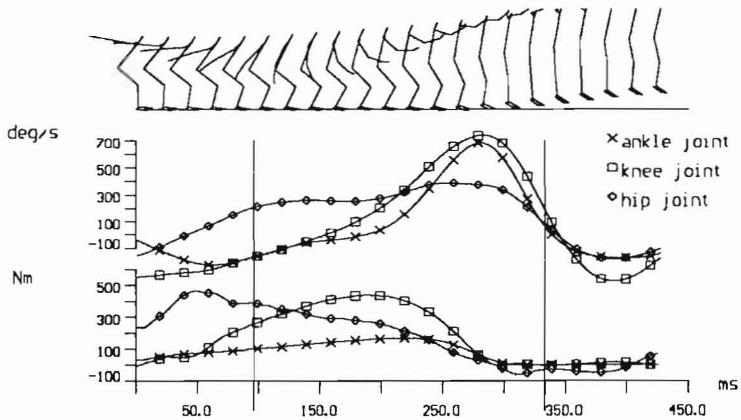
Six male subjects participated in the study: three professional ballet dancers and three elite volleyball players. In the ballet specific jump (BSJ) the legs were outward rotated, one foot was placed in front of and close to the other foot and the upper body kept upright. In the airborne phase the feet were shifted in front of each other three times. It was necessary to jump as high as possible to provide enough time in the air to accomplish these movements. Three elite volleyball players performed the jump used for the smash (VSJ) including a three step preliminary run up and a forceful arm swing. Afterwards all six subjects performed SQJ and CMJ with the arms held akimbo. The movements were recorded with 16 mm film (500 frs/s), ground reaction forces with a force platform (1000 Hz) and EMG from 7 leg muscles with surface electrodes (1000 Hz). The body was transformed into a four (SQJ, CMJ) or six (BSJ, VSJ) segment model and kinematic data were calculated from the lowpass filtered (8 Hz) digitized film coordinates. Net joint moments were calculated by inverse dynamics. Total work were calculated by integration of the net joint power with respect to time. The jumps were analysed in the time interval from body centre of mass (BCM) was lowest (s.j.) until the toes left the platform (t.o.). The strategy of the jumps was determined on the basis of angular kinematics and the pattern of net joint moments of the two dominant joints. The timing of the different joints contribution to the vertical velocity of the centre of mass of the segment "head, arm and trunk" (HAT) were calculated by computing the vertical velocity difference between HAT and the markers of the hip, knee and ankle joint . The calculations was done in accordance to Bobbert and van Ingen Schenau (1988).

## RESULTS

For BSJ the jumping height (h) was 0.22-0.28m.The work contribution from the knee

Angular velocity and net joint moments for subject HP performing a BSJ (top) and for subject TK performing a VSJ (bottom). The dotted lines denote s.j. and t.o.



and ankle joint were 50-70% and 47-63% of the total work respectively while the work at the hip joint showed a negative contribution of 13-17% caused by a net hip flexor moment. Because of the specific ballet position the hip extension took place in the frontal plane and m.gluteus maximus could not contribute to the extension. The concentric activity in m.rectus femoris could partly explain the hip flexor moment. The absolute work contribution from the ankle joint was between 107-169 Joule. This was two to three times bigger than the absolute work contribution performed in the CMJ by the subjects. The knee and ankle joint initiated the extension phase simultaneously and the net joint moments peaked simultaneously (figure top) and the strategy was defined as a simultaneous strategy. The demand of keeping the upper body upright caused the joint extension to pass on in a closed kinematic chain while pushing at the heavy trunk. This could explain the observed simultaneous strategy. For VSJ h was 0.31-0.45m. The work contribution from the knee and hip joints were 22-60% and 35-62% of the total work respectively. The hip joint began the extension phase before the body centre of mass had reached its lowest position (s.j.). The knee extension began 40-100ms after s.j. The peaks of the net joint moments of the hip and knee showed a similar pattern (fig bottom). Accordingly, the strategy was defined as a sequential strategy. The forceful arm swing would press down and give negative momentum in the downward phase and by this delaying the knee extension (Harman et al 1990 ). This could partly explain the sequential strategy. In SQJ and CMJ h was 0.22-0.36m and 0.33-0.40m. The work contribution from the knee was 64.5%(SE 5.9) and 76.0% (SE 9.2) and from the hip 18.8% (SE 5.8) and 13.3% (SE 8.7). For SQJ the strategies could be confirmed by the onset of EMG. One ballet dancer and one volleyball player performed SQJ and CMJ with a simultaneous strategy while the other four subjects used a sequential strategy. When the subjects performed SQJ and CMJ the choice of strategy seemed individual but consistent. Both in the simultaneous and the sequential strategy the peak vertical velocity difference for the hip, knee and ankle joints was reached in a proximo-distal sequens. This means that the peak contribution to vertical velocity of HAT was reached first from the hip extension and last from the ankle extension. Even though the simultaneous strategy was characterized by a simultaneous onset of hip and knee extension and a simultaneous rise and peak in the net joint moment of the hip and knee joint, the peak joint contribution to vertical velocity passed on in a sequential proximo-distal sequens.

**CONCLUSION.**

In a maximal vertical jump performed during a ballet dance or during a volleyball play, the technical demands preset the jumping strategy. When the subjects were asked to perform SQJ and CMJ the choice of strategy seemed individual and not related to training background.

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