# MECHANICS OF FOUETTÉ TURN IN CLASSICAL BALLET

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## INTRODUCTION

Skilled ballet dancers can continuously perform Fouetté turns for more than 30 revolutions. They obtain the angular momentum for the next revolution from the swing of the gesture leg and the arms while the frictional force on the supporting foot is large [1, 2]. The continuity of the turn will depend on the behaviour of the frictional forces and the resultant torque around the vertical axis through the center of body mass. Thus, variables such as moment of inertia of the body, coefficient of friction and the area of the foot contact will regulate the continuity of the turn. However, the mechanics of the turn associated with such variables has not yet been investigated.

The purpose of this study was to investigate the mechanics of the Fouetté turn for one revolution using a simple model of the supporting leg and the remainder of the body.

## METHODS

The dancer's body (mass 50kg) was modeled as two cylinders, the supporting leg (b) and the remainder of the body (a). The rotations of the cylinders were regulated by the angle, $\phi_c$ between the angle $\phi_a$ of the shoulder line and the angle $\phi_b$ of the supporting foot using a sine function. The radius of the foot contact area, the moment of inertia of the whole body except supporting leg and the normal ground reaction force were defined using monotonic quintic functions. The coefficient of friction ($\mu$) was varied between 0.1 and 0.35. One revolution was simulated from the time when the dancer's moment of inertia is the largest, assumed to take one second (Figure 1 a.).

## RESULTS AND DISCUSSION

Figure 1 shows one trial in which $\phi_b$ reached $2\pi$ at the end of the turn. $\mu$ was 0.20 and $\phi_c$ was initially -0.42 rad. The angular acceleration of $\phi_c$ at the beginning affected the time the twisting torque became larger than the maximum frictional force. The twisting torque should be less than the maximal frictional torque if the foot is not to slip. When the time to start twisting was late, the angle $\phi_b$ didn't reach $2\pi$ at the end. The acceleration of $\phi_b$ has to be large enough before the foot stops to achieve one revolution of the supporting leg. Thus the dancer has to quickly reduce the moment of inertia of the remainder of the body during twisting. One revolution of Fouetté turn is sensitive to the value of $\mu$ though the dancer could change the timing of the swing and foot contact.

## CONCLUSIONS

One revolution of Fouetté turn can be performed by regulating the speed of the gesture leg and arm movement according to the coefficient of friction between the floor and the shoes.

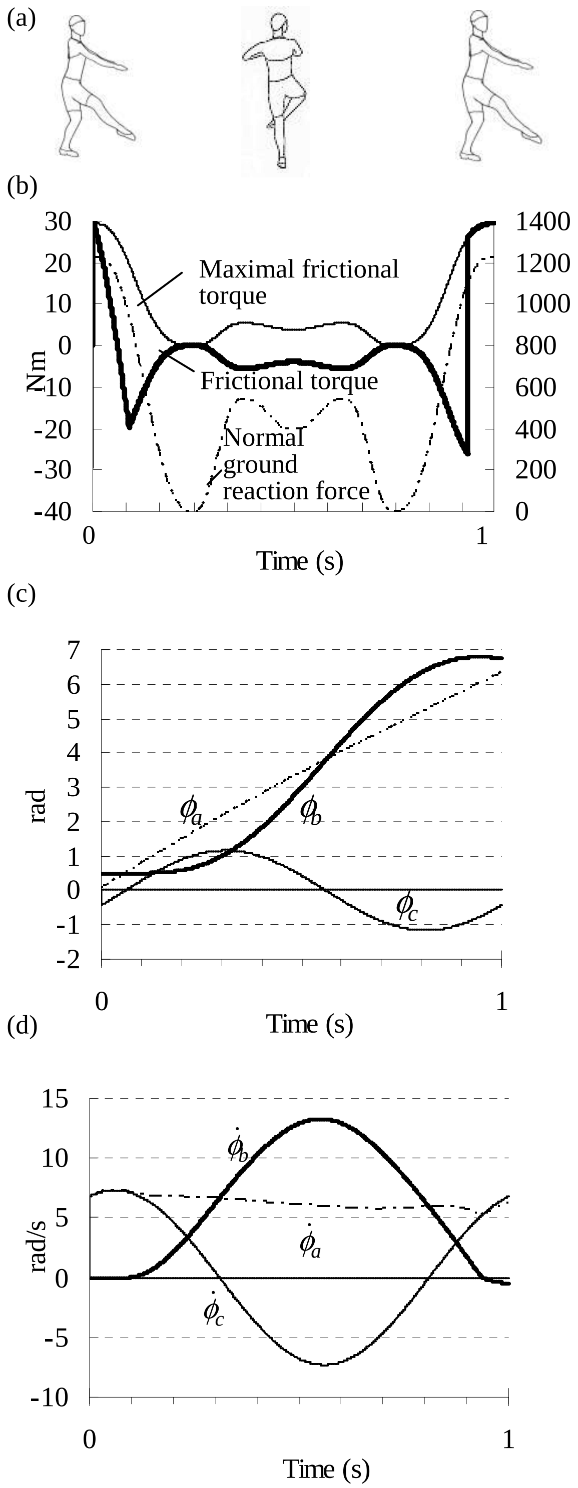


**Figure 1**: (a) One revolution of a Fouetté turn. (b) Forces exerted. (c) angles. (d) angular velocities.

## REFERENCES

1. Laws K. *The physics of dance.* New York: Schermer Books, 1984
2. Imura A. et al, *Hum Mov Sci.* **27**:903-913, 2008.