

# Three-Dimensional Inverse Dynamics in a Forward Pike and Twist Dive Maneuver

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## Summary

For the performance of a gold medalist of spring board diving competition, an inverse dynamics was conducted. The joint positions were acquired from a competition footage using digitizing the points. The analysis of forwards 2 and 1/2 somersaults with 2 twists in the pike position showed the inverse dynamics for a forward pike and twist maneuver showed that the diving athlete could control the complicated changes of the posture by several small joint moments.

## Introduction

In spring board diving competition, athlete competitors have to bend and twist their whole bodies in quite short time, competing of the proper amounts of rotation and revolution upon completion of the dive and entry into the water. To perform high demanding maneuvers as forward pike twist dive, competitive divers adequately have to generate joint torque to keep or change their joint angles in three-dimension. Therefore, in this study, we conducted inverse in forward pike twist dive maneuver using a competition footage of the performance by a world medalist that shows the forwards 2 and 1/2 somersaults with 2 twists in the pike position.

## Methods

In this study, we used the competition footages from 3 m springboard diving in the 2016 Olympics and obtained the whole postures of during performance. The movies of the performance by the Olympic gold medalist were taken in the sagittal and frontal planes [1]. The 15 joint positions of the divers for each frame were acquired using an image analysis software Image J (National Institutes of Health, USA). The positions of the center of gravity of the whole body on the two planes were aligned to the same parabolic motion to calculate three dimensional coordinates of the joint positions. The time series data of the coordinates of the joint points were connected using a spline curve, and then the coordinates were interpolated as the frame rate corresponded to 250 fps while the original frame rate is 59.77 fps. We analyzed inverse dynamics of the motion with Visual 3D (HAS-motion, Kingston CA).

## Results and Discussion

Figure 1 shows the somersault and twist rotation angles, the joint angles, and the joint torques. Diving motion is divided into three phases; the first somersault phase from the start to 0.51 s (red background), the twists and 1/2 somersault phase from 0.51 to 0.90 s (white background), and the second somersault phase from 0.90 to the end (blue background). The

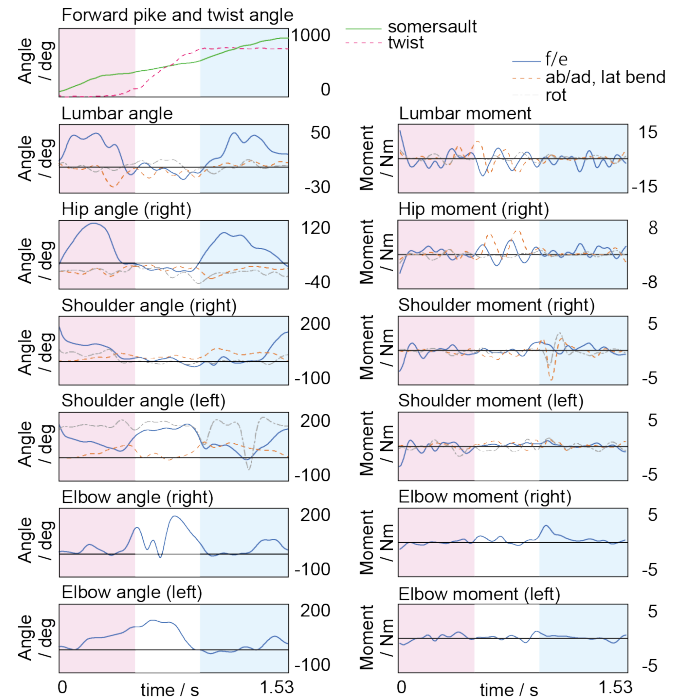


Figure 1: Rotation angles, joint angles and joint torques.

right hip only is included in the figure because both of the lower extremities show similar joint movements and torques. The lumbar and hip joints showed large angles in both of the somersault phases. Also, the shoulder and elbow joints showed complicated movements reproducing the actual postures of the upper extremities. On the other hand, any joints generate small moment several times during the performance. This means that the joint angles of the forwards 2 and 1/2 somersaults with 2 twists in the pike position could be controlled by several small joint moments.

## Conclusions

The inverse dynamics for a forward pike and twist maneuver showed that the diving athlete could control the complicated changes of the posture by several small joint moments.

## Acknowledgments

A part of this research was supported by The Uehara Memorial Foundation and JKA and its promotion funds from KEIRIN RACE.

## References

- [1] Cao Yuan ALL divers from Rio2016!: <https://www.youtube.com/watch?v=xqSJXcs14jA&t=602s>.