GENERATION OF FORWARD ANGULAR IMPULSE IN TASKS WITH BACKWARD TRANSLATION IS ACHIEVED BY REDIRCTING THE REACTION FORCE RELATIVE TO CENTER OF MASS

[1] Witaya Mathiyakom and [2] Jill L McNitt-Gray
[1]Andrus Gerontology Center and [2]Department of Kinesiology, Biomedical Engineering, Biological Sciences, and University of Southern California; e-mail: mathiyak@usc.edu

INTRODUCTION

Successful performance of whole body movements is dependent on the ability of the performer to satisfy both linear and angular impulse requirements of the task during contact with the environment [1]. Previous research indicates that mechanisms of generating linear and angular impulse vary with tasks [2]. While linear impulse in both forward and backward translating tasks is affected by the orientation of the hips relative to the feet (leg angle) and lower extremity muscle activation patterns, angular impulse is affected by the moment arm between the reaction force and the center of mass (CoM) and the magnitude of the reaction force. During forward translating somersaults (e.g. reverse somersault), modification in CoM position relative to the center of pressure (CoP) is limited by anatomical constraints (e.g. dorsiflexion). As a result, the magnitude of the moment arm is regulated by redirecting the reaction force. In contrast, during backward translating somersaults (e.g. back somersault), the moment arm is regulated by reorienting the CoM relative to the CoP prior to rapid joint extension during the push phase. During the take-off phase of the inward somersault (backward translation, forward rotation), the foot contact duration is approximately half of the back and reverse somersaults and the reaction force passes posterior relative to the CoM. This time limitation for generation of linear and angular impulse led us to hypothesize that magnitude of the moment arm during the take-off phase of the inward somersault would be regulated by redirecting the reaction force rather than altering the CoM position relative to the CoP. Redirecting the reaction force was expected to be achieved by redistributing the lower extremity NJMs.

METHODS

Six (2 females and 4 males) highly skilled divers performed a series of the inward somersault (IS) and inward timer (IT) take-offs from a force platform onto a landing pit using their competitive style. Sagittal plane kinematics and reaction force data were simultaneously collected and synchronized at the time of plate departure. Newtonian mechanics were used to compute the lower extremity NJMs.

RESULTS AND DISCUSSION

Between-task differences in reaction force direction and trunk-leg coordination indicated that angular impulse is generated by redirecting the reaction force relative to the CoM (Figure 1). Redirection of the reaction force was achieved by a redistribution of the knee and hip NJMs during the take-off phase. These results support the hypothesis that angular impulse is regulated by redirecting the reaction force. As expected, more posterior directed reaction forces were associated with trials with large knee NJMs in relation to hip NJMs (Figure 2).

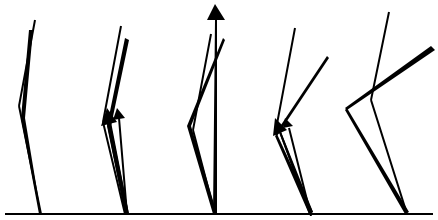

Figure 1. Orientation of the trunk, leg, and reaction force (arrow) from initiation (left) to plate departure (right) during the take-off phase of the inward timer (thin line) and inward somersault (think line).

Redistribution of the lower extremity NJMs and a more posterior oriented hip relative to the CoP (leg angle greater than 90 degrees) affected the orientation of the reaction force. At the time of peak horizontal reaction force, leg orientation and magnitude of the horizontal reaction force were significantly larger during the take-off phase of the IS as compared to the IT. The leg orientation explained only 55% of the variance in the reaction force direction, whereas the difference in the knee and hip NJMs explained 88% of the variance in the reaction force direction (Figure 2). These results further substantiate the role of redistribution of NJMs on reaction force redirection relative to the CoM in whole body movements [3].

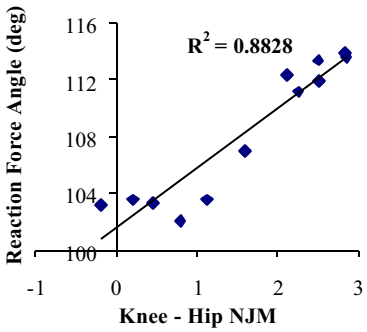

Figure 2. Correlation between the differences in knee and hip NJMs and reaction force direction at the time of peak horizontal reaction force.

CONCLUSIONS

Generation of the forward angular impulse and backward linear impulse during take-off phases with limited foot contact duration is primarily achieved by redirecting the reaction force relative to the CoM. Backward leg orientation facilitates generation of backward directed reaction force in global space. In addition, redistribution of the lower extremity NJMs redirects the reaction force relative to the leg and CoM.

REFERENCES

1. Miller DI, *Biomechanics in Sports*, 326-348. 2000.
2. Mathiyakom et al., *J Applied Biomech* (submitted).
3. van Ingen Schenau et al., *Neuroscience*, 197-20. 1992.