High Speed Video Acquisition and Analysis of Taekwondo Kicks

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Abstract

Taekwondo is a form of martial arts that is characterized by techniques such as kicks, spins, and strikes. We hypothesize that through these movements, angular momentum is an essential characteristic of the motions used in Taekwondo. Prior work [1-3] omits consideration of angular momentum, so this work is novel. An improved understanding of angular momentum in Taekwondo and other martial arts would allow improved modeling of the flow of energy and momentum in martial arts, as well as create improved kinematic models of Taekwondo forms. In order to study our hypothesis, we constructed a large "Lazy Susan", that a martial artist stands on while performing various motions. High-speed videos of each performance were collected and the footage was analyzed. Our primary analysis determines dynamic rotation rates and amount of angular momentum during a movement. Our primary conclusion is that frictional contact with the ground and development of angular momentum via applied torques is an essential component of Taekwondo motions.

Introduction

Taekwondo is a Korean martial art that has grown popular all across the United States. Taekwondo has specific kicks and punches that distinguish this martial art from other types, including: head-height kicks, jumping spinning kicks, and fast kicking techniques. We have found that biomechanics research into Taekwondo has focused on linear elements of martial arts and overlooks angular components of the sport. Our hypothesis is that through the kicks and movements of Taekwondo, angular momentum is essential to the motions and forms. Further research into this idea will allow more accurate kinematic models and improved analysis of specific movements.

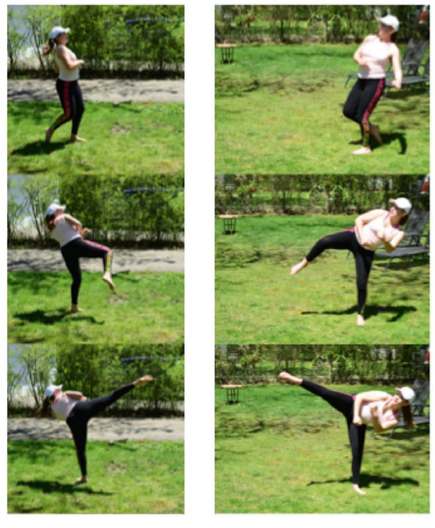

Figure 1. Taekwondo kick. This figure depicts a martial artist performing a roundhouse kick, the kick is performed with a rotation of their body as well as with rotation of their foot on the ground.

Methods

In order to analyze rotational motion, we constructed a large "Lazy Susan" disk and borrowed high speed camera. The disk was constructed out of plywood with a radius of .6096 meters The moment of inertia of the Lazy Susan was calculated to be 4.162 kg m^2 The martial artist will perform on top of the disk while the camera films the results.

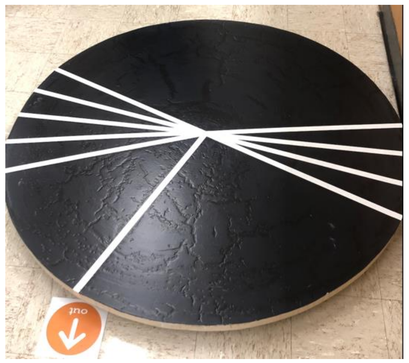

Figure 2. The disk.

Figure 3. Photron FASTCAM Mini AX 100

Results

$$\Omega = -\frac{2mv}{(m+M)R}$$

$$E_{in} = [\frac{m}{2}\left(1+\frac{m}{M}\right) + \frac{m^2 M}{(m+M)^2}]v^2$$

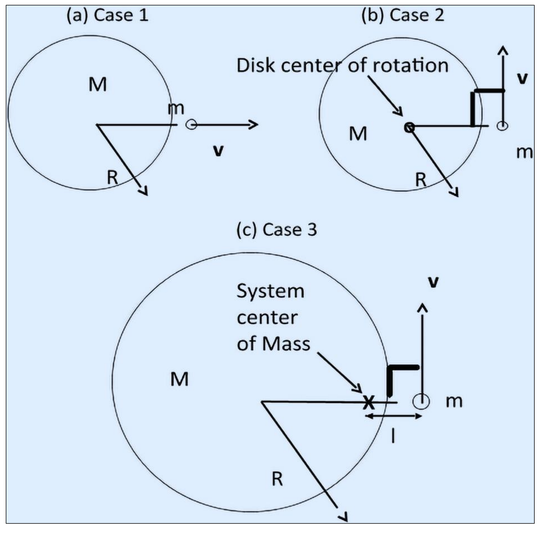

Figure 4. Angular momentum and energy equations.

Figure 5. Video analysis.

Conclusions

- I learned how angular momentum is involved in a Taekwondo system.
- I constructed the disk, including painting and designing the reticle on the disk.
- I learned how to use a high speed camera, as well as skills like video acquisition.
- I learned how to calculate field of view and frame rate of a high speed camera.
- I performed multiple equations to solve for moment of inertia, angular momentum, and energy.
- I co-authored a published paper detailing the involvement of angular momentum in martial arts.

References

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Acknowledgements

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