Kinetics of the Skateboarding Kickflip

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Summary

Kickflips are a common maneuver used by intermediate and advanced skateboarders to hop onto, off of, and over obstacles. This paper provides descriptive biomechanical data on the vertical ground reaction forces and in-shoe pressures exerted on the foot during successful skateboarding kickflips. These data show that skateboarders may intentionally induce higher landing forces during kickflips and suggests that skateboarders may benefit from exercises that increase jumping height.

Introduction

Despite the global popularity of skateboarding, little is known about the biomechanics of the sport. In this study, we aim to partially rectify this paucity of hard data by describing the kinetics of a common movement used by intermediate and advanced skateboarders: the kickflip. A kickflip is a jumping maneuver used by skateboarders to hop onto, off of, and over obstacles. It is similar in motion to an ollie [2] but differs slightly as it incorporates a kicking or flicking motion of the foot during the airborne phase of the jumping movement that causes the board to rotate in the air about its long axis underneath the skater's feet. As part of a larger study to develop a kickflip simulation machine, we were curious about how much force and toe box pressure was generated by skateboarders in order to successfully take off and land while performing kickflips.

Methods

Seven male and highly skilled skateboarders (mass = 75.1 ± 11.4 kg) performed ten kickflips from a standing position on a large force plate. Vertical ground reaction force (VGRF) data were measured using an AMTI force plate, while RSscan pressure insoles in both shoes measured the distribution of the forces under the plantar surface of each foot. Three Halm piezoceramic transducers were also used to measure the local pressures between foot and shoe in the toe area. Sensors were place on the dorsal surface of the 3rd and 5th distal phalanges and the lateral aspect of the 5th metatarsal. VGRF and Halm pressure data were filtered using a Butterworth digital filter with a cutoff frequency of 100 Hz. High speed digital video was used to visually aid in the analysis of these rapid movements using a JVC camera.

Results

An example VGRF force-time curve is shown in Figure 1. Typically the VGRF rose slightly above one bodyweight (BW) during the first 200 ms of the movement as the subject initially plantarflexed their ankles on the skateboard before rapidly lowering their center of mass by flexing their ankles, knees, and hips. The VGRF then rose rapidly as the subjects jumped into the air off their back foot while their front foot controlled the motion and direc-

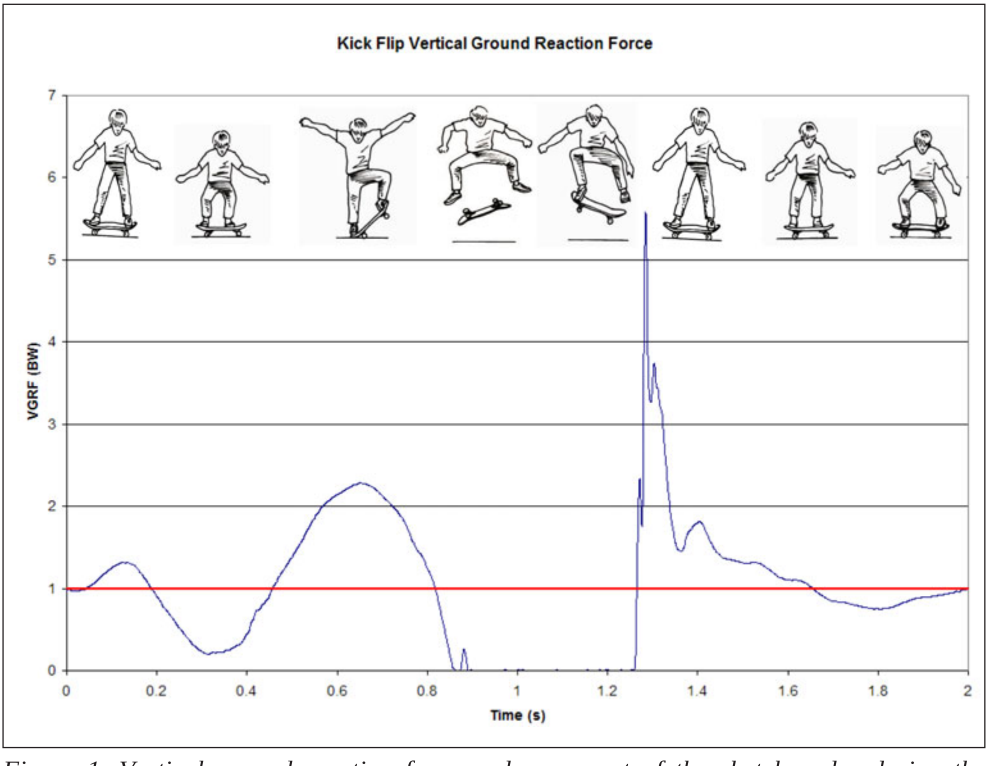

Figure 1. Vertical ground reaction force and movement of the skateboarder during the kickflip movement.

tion of their skateboard. In-shoe plantar pressure data revealed that most of the force acting underneath the foot occurred across the hallux and the first through fifth metatarsal heads of the back foot at the time of takeoff (TO). Average peak TO VGRF's were found to be 2.05 ± 0.17 BW's. TO velocities were calculated using the initial change in vertical impulse which was then used to calculate the change in height of the subjects' center of mass [1] for each jump. The average jump height was found to be 25.8 ± 9.1 cm, while the average flight phase (TO to L) lasted 448 ± 30 ms. During the first 140 ms of the flight phase the subjects used their front foot to kick the board causing it to rotate or flip underneath their feet along the long axis of the board. Average peak pressure across the 3^{rd} phalange, 5^{th} phalange, and 5^{th} metatarsal head during this kicking motion were found to be 147 ± 80 kPa, 190 ± 107 kPa, and 138 ± 51 kPa respectively. After one full rotation the subjects caught and aligned the board back underneath their feet using their back foot for landing (L). Typically the board landed initially first with the subject landing on top of the board quickly thereafter. In some trials, the board, front foot, and back foot all landed at once and only a single VGRF L peak was recorded, however in most trials three peaks were recorded as the board, back foot, and front foot landed sequentially. Average peak L VGRF forces were found to be 4.61 ± 1.19 BW's during landings across all the subjects. Plantar pressure was more evenly distributed across the medial heel and metatarsals of both feet during landings.

Conclusions

The magnitudes of the VGRF during takeoff and landing were similar to previous studies by Frederick et al. who studied skateboarders performing ollies up onto and off of a 45.7 cm wooden platform [2]. In their study, TO forces were found to be 2.22 BW's when their subjects first rolled onto a force plate and ollied up onto the platform. Later when their subjects ollied off the 45.7cm platform down onto a force plate at ground level landing forces ranging from 4.26 to 5.38 BW's were recorded. Given that our subjects were stationary and landed at the same height they took off from we would expect lower landing forces in our study, however this was not the case. Landing forces in our study ranged from 2.9 to 6.4 BW's. A closer look at the high speed video revealed a possible cause for this result. As the board rotated underneath the feet of the subjects and the riders reached the peak of their jump, they had to quickly stop the board's rotation and align it underneath their feet for landing. Some of the skaters in our study intentionally spiked their landings as soon as they stopped and aligned the board underneath their feet in order to stabilize themselves and ensure they would land on top of their skateboards. Other subjects seemed to land more naturally after stopping their boards from rotating and let the effects of gravity force themselves to land on top of their boards. It is not known at this time which landing method is more beneficial for consistently landing a kickflip.

Further analysis of the VGRF data also shows the magnitudes and shape of the force-time curve are similar to other studies examining countermovement vertical jumps [1], [3]. McClay et al. studied vertical jumps in professional basketball athletes and found average TO forces to be 1.7 ± 0.52 BW's and L forces to be 4.3 ± 1.16 BW's, though no jump heights are reported. Dowling and Vamos (1993) examined vertical jumps of 97 young adults and found TO forces ranging from 1.8 to 2.8 BW's for jump heights similar to those recorded in our study.

The fact that ollie and kickflip movements so closely mirror other jumping movement sports such as basketball and volleyball, at least on a kinetic level, suggests that skateboarders may benefit from similar training exercises used in these more traditional sports to increase jump height ability. If skateboarders could increase their jumping ability they could theoretically be able to jump over higher objects with their boards or increase the number of revolutions the board completes during kickflips.

References

[1]. J.J. DOWLING, L. VAMOS, Identification of Kinetic and Temporal Factors Related to Vertical Jump Performance, J. Appl. Biomech., Vol. 10, 95-110, 1993.

[2]. E.C. FREDERICK, J. DETERMAN, S. WHITTLESEY, J. HAMILL, Biomechanics of Skateboarding: Kinetics of the Ollie, J. Appl. Biomech., Vol. 22, 33-40, 2006.

[3]. I.S. MCCLAY, J.R. ROBINSON, T.P. ANDRIACCHI, E.C. FREDERICK, T. GROSS, P. MARTIN, G. VALIANT, K.R. WILLIAMS, P.R. CAVANAGH, A Profile of Ground Reaction Forces in Professional Basketball, J. Appl. Biomech., Vol. 10, 222-236, 1994.