



ISB 2013  
BRAZIL

XXIV CONGRESS OF THE INTERNATIONAL  
SOCIETY OF BIOMECHANICS

XV BRAZILIAN CONGRESS  
OF BIOMECHANICS

## BIOMECHANICAL ANALYSIS OF SQUAT AND COUNTER MOVEMENT JUMP IN SKATER

<sup>1</sup>Zimi Sawacha, <sup>1</sup>Fabiola Spolaor, <sup>1</sup>Martina Negretto, <sup>1</sup>Claudio Cobelli  
Department of Information Engineering, University of Padova, Italy

### SUMMARY

Recently, the practice of skateboarding is becoming increasingly popular among the younger generation, so as to count the number of practitioners worldwide of about 18.5 million in 2002, of which 12.4 million people in the United States of America [1]. In Italy, despite the small size of the phenomenon, there is a number of practitioners who were able to achieve significant results at the international level [2].

Despite this apparent growth, skateboarding is really under-represented in the scientific literature. The aim of this study was to investigate differences between skaters and a group of control subjects matched for age and BMI in performing either countermovement jump (CMJ) or squat jump (SJ). Furthermore the relationship between jump performance and balance was also investigated. Motion analysis technique was then applied in order to evaluate jump biomechanics and assess each subject posture by means of two force plates coupled with a stereophotogrammetric system and 2 plantar pressure systems.

### INTRODUCTION

Skateboard is classified as sport between the activities of aerobic endurance and the activities of rapid strength. Motor coordination is its key element. This framework makes it possible to stimulate and train the conditional capacities of endurance, strength and speed, and almost all of the general coordination skills learning, organization and motor control, and coordination skills special combination, imagination, balance, spatial orientation-time, motor reaction. The Ollie is the basic skateboarding maneuver and consists of a jump where skate and the athlete rise from the ground and return in continuous movement [3]. Given that the Ollie maneuver is involved in all skateboarding movements it is important to study the technique of jump in skaters. The objective of the research presented herein is to investigate and describe the differences in the biomechanics of jump between high level skaters (SG) and a control group (CG) consisting of deconditioned subjects. Furthermore, by considering the role that balance plays in skateboard, postural control was also assessed in the aforementioned group of subjects. Two types of jump were investigated: CMJ and SJ. Motion analysis technique was applied in order to evaluate both jump and posture biomechanics.

### METHODS

Ten subjects were enrolled in this study: 5 professional skater (SG: mean BMI  $22 \pm 0.9$  kg/m<sup>2</sup> and mean age  $21 \pm 2$  years), and 5 control subjects (CG: mean BMI  $22.32 \pm 3.5$  kg/m<sup>2</sup> and mean age  $23 \pm 1$  years). Subjects were asked to perform 6 jumps (3 SJ and 3 CMJ) and to stand on a force plate for 60 seconds either with their eyes closed or open [4]. During the static acquisition the subjects were asked to stand with their arm along the body and their feet assuring



Figure 1: Subjects during static acquisition (L5, RCA and LCA markers are highlighted).

an angle of 30° in between by means of a cardboard guide. A 6 cameras stereophotogrammetric system (60/120 Hz BTS, Padova), two plantar pressure systems (150 Hz, Imagortesi, Piacenza) and two Bertec force plates (960Hz, FP40,60) were used. The signal coming from all systems were synchronized [5]. Three markers were applied on each subject (see Figure 1) by means of double sided tape on the following anatomical landmarks: the fifth lumbar vertebra (L5) and the posterior aspect of the calcaneus (RH and LH). With respect to the CMJ, each jump was divided in 2 phases: unweight and propulsion. Unweight phase was defined as the interval between the starting position of the jump to the lowest point reached by L5, i.e. at the point of maximum bending of the knees; instead propulsion phase was defined as the interval between the end of the unweight phase to the take off (i.e. the instant when the vertical ground reaction vector was equal to zero after the beginning of the jump). With respect to the SQ only the propulsion phase was considered according to [6]. During SJ the subjects were instructed to start their jump from a position of 90° of knee flexion.

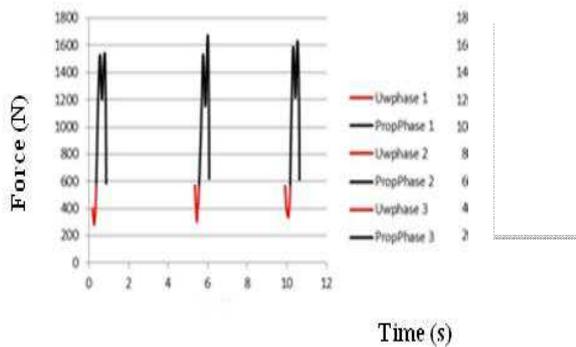


Figure 2. Vertical component of Ground Reaction Forces of one skater's three CMJ: Propulsion Phase (black) and Unweight Phase (red).

For each jump the following variables were evaluated: Flight Phase, Minimum Unweight Phase (only for CMJ), Maximum Propulsion Phase and related Flight Time, Ground Reaction Force and Height of the jump (from heel in SJ and from L5 in CMJ) were calculated as in [6]. Smart Analyzer, Matlab R2011 software were used to perform the analysis. With respect to the posture analysis the following parameters were estimated: ellipsis 95%, sway area, path, path x, path z, mean velocity, mean velocity x, mean velocity z (where x and Z are the medio-lateral and anterior-posterior direction) [4].

Statistical analysis was performed using the software SPSS (Statistical Package for Social Science) version 19, distributed by IBM, which allows for a detailed analysis of the data: descriptive statistics and the Student T test ( $p < 0.05$ ) were performed.

## RESULTS AND DISCUSSION

The results of the biomechanic analysis of the jump revealed that the protocol used, both in term of instrumentation and parameters analysis have allowed to highlight different biomechanic characteristics on the two groups of subjects (see Table 1). These results were in agreement with the literature describing the skateboard jumping technique [3]:

Variables	Jump	SG		CG		$p < 0.05$ Equal variances assumed
		Mean	St. Dev	Mean	St. Dev	
Max Propulsion (%BW)	SJ	1730,19	228,39	1516,99	220,89	,015
	CMJ	1635,46	101,31	1410,59	168,33	0,01
Min Unweight (%BW)	SJ					
	CMJ	4,71	0,04	3,80	0,01	0,00
High of Jump (mm)	SJ	481,29	54,49	430,39	51,41	,014
	CMJ	415,43	54,98	340,49	45,04	,000
FlightPhase (ms)	SJ	537,78	31,79	502,22	45,80	,020
	CMJ	583,33	25,20	541,11	38,25	,001

Table 1: Mean, standard deviations and significant differences ( $p < 0.05$ ) between the two groups.

a longer duration of flight phase, a higher jump and a greater development of strength during the propulsion phase characterized the SG's jump when compared with CG. This can be explained with the typical jump technique of the ollie, in which the principal element is represented by the elevation of the legs from the ground [3]. A higher position of both L5 and the heels in CMJ reflects the habit to overcome high obstacles with the board which is also typical of this discipline. The major propulsion registered during jump in SG demonstrates a workout that involves more muscles related to this specific task as quadriceps and gastrocnemius muscles. The latter are two biarticular muscles that control the hip, knee and ankle respectively in terms of flexion of the thigh on the trunk, extension of the leg on the thigh and extension (or plantar flexion) of the ankle. These are the movements which are typically involved in performing the ollie. results of posturographic analysis didn't reveal differences between the 2 groups.

## CONCLUSIONS

From these results it can be concluded that training with skateboarding, causes an increase in elevation and in speed during the loading phase of the jump and the driving force in the lower limbs. Furthermore an increment of intramuscular coordination was observed. Compared to existing studies on the biomechanics of skateboarding, this work has assessed the biomechanics of two different type of jump in a small group of skaters and controls. In addition, given the small research in this field, it could be a new input for the future of this fascinating scientific research.

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