DIFFERENCES BETWEEN JUMPS ON HARD AND ELASTIC SURFACES

Juergen Krug, Hans-Joachim Minow, and Petra Jassmann
University of Leipzig, Faculty of Sports Science, Germany

The purpose of the present study was to analyze differences of jumps under several conditions. A measuring unit with two dynamometric platforms and a synchronized highspeed video was used. One platform was prepared with a special elastic element of elastic swing floor. Participants were 160 sport students (72 male, 88 female). Tasks were counter movement jumps and drop jumps. In this group 12 students (5 male, 7 female) performed the test program with additional EMG signal recording. The results showed that the contact time and the height of jumps were significantly differentiated between the performances on the hard and the elastic surfaces. On the special elastic surface the contact time was shorter and both types of jumps were higher. In addition, the ground reaction force and the EMG activity were different under the two conditions.

KEY WORDS: counter movement jumps, drop jumps, contact time, EMG

INTRODUCTION: Take-off movements were executed in the several disciplines of sports under different conditions. For example, in gymnastics, diving and figure skating we analyzed some differences under the specific conditions (Krug, 1997). These conditions (run-up vs. standing, one- or two-legged jumps, vertical or horizontal jumps, flight with translational or rotational movements, hard or elastic surfaces) lead to different variants of technique. Selected parameters of these analyses showed considerable differences (table 1).

Table 1 Selected Characteristics and Parameters of the Take-off in Figure Skating, Gymnastics and Diving

Characteristics	Figure skating	Gymnastics		Diving			
		Acrobatic	Vaulting	3m-Springboard		Platform	
				Stand	Run-up	Stand	Run-up
take-off time	0.12-0.16	0.11-0.13	0.09-0.11	0.3-0.5	0.25-0.45	0.17-0.25	0.09-0.15
max height [m]	0.65	1.70	1.00	1.20	2.00	0.55	0.50
surface characteristics	hard	elastic	elastic springboard	elastic springboard		hard	
one- or two-legged	one- or two-legged	two-legged	two-legged	two-legged		two-legged	

Although these differences exist, in the training coaches and athletes of these disciplines have used counter movement jumps (CMJ) and drop jumps (DJ) on hard surfaces. This problem was the reason for analyzing jumps on hard and elastic surfaces. It was hypothesized that important parameters of jumps on hard and elastic surfaces are different. For this an experiment with sport students was conducted. They had to perform counter movement jumps and drop jumps.
There are some investigations in counter movements and drop jumps (e. g. Hochmuth, 1967; Bobbert et al., 1986, 1987; Frick, Schmidtbleicher & Wörn, 1991; Virmavirta, Avela & Komi 1995; Kibele, 1998; Hatze, 1998). However, all these investigations were focussed only on jumps on hard surfaces. Therefore, a deficit exists in analyses of jumps on elastic surfaces and their differences to hard surfaces. In a study of take-off movements in gymnastics (floor exercises and vaulting horse) the stretch shortening cycle reduced to a tension shortening cycle (Krug et al., 1998). For that reason, it was hypothesized that drop jumps are more similar to a tension shortening cycle.

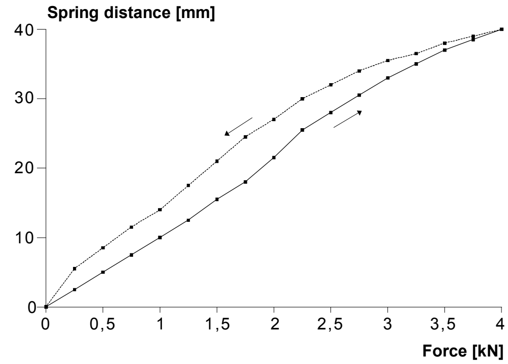

Figure 1 – Characteristics of vertical components of the elastic swing floor on the dynamometric platform (Knoll 1999).

METHODS: We used a measuring unit with two dynamometric platforms Type FKS-Leipzig (Härting et al., 1982). One platform was prepared with a special elastic element of the elastic swing floor (Spieth-Offical Manufacturers of the International Gymnastics Federation). The tests of the elastic characteristics (Figure 1) were described by Knoll (1999). The static and dynamic parameter errors of the platform signal with the elastic element were lower than 5%. Both platforms were fixed in the foundation. The surface level of both platforms was equal to the bottom of the gym hall. The measuring unit is shown in Figure 2.

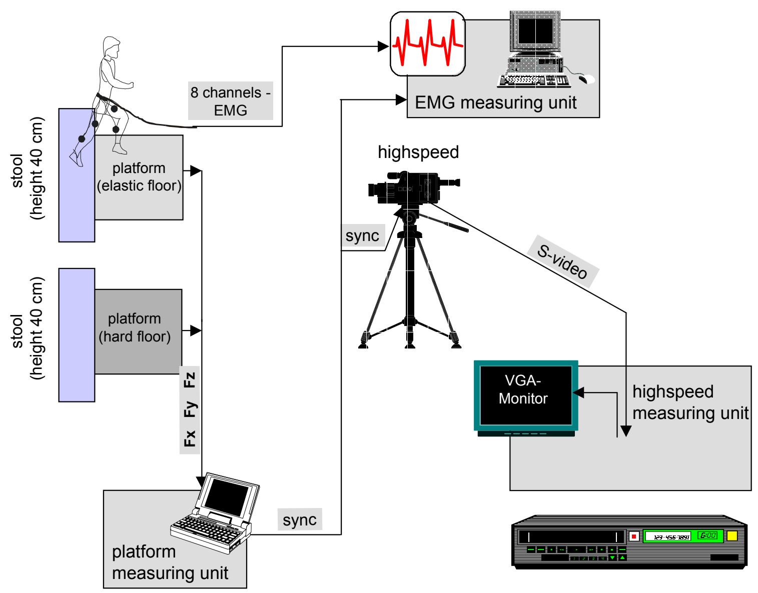

Figure 2 – Measuring unit with hard and elastic surface.

Test program for all subjects:
- warming up
- 1 counter movement jump and 2 drop jumps from gym stool (40 cm) on hard surface
- 1 counter movement jump and 2 drop jumps from gym stool (40 cm) on elastic surface

The subjects performed all jumps barefooted. The particular jump with the highest performance on the hard and elastic surface was selected for statistical analyses.
In the experiment 160 sport students took part (72 male, 88 female). In this group 12 students (5 male, 7 female) performed the test program with EMG signal recording of the m. gastrocnemius lateralis, m. vastus lateralis, m. rectus femoris, m. biceps femoris on both sides (System NORAXON, MYO 2000, sampling rate 500 Hz). The beginning and the end as well as the activity of all above listed muscles were obtained from the rectified and smoothed EMG-signal. The dynamometric platform (sampling rate 500 Hz), the highspeed video (frequency 250 Hz) and the EMG signal were synchronized. The trigger signal was automatically started by a light barrier.
Contact time was measured between the first and last ground contact. The height of jumps (h_{CM}) was approximately calculated by software (Perlt, 1996) with following formula:

$$h_{CM} = \frac{g}{8} t_f^2$$

The results of the height of flight were given to the subjects immediately after the attempts.

where : h_{CM} = Center of mass height, t_f = Flight time, g = acceleration of gravity

In this paper we focus the statistical analyses on the flight height and contact time (the paired samples T-test was used). A described analysis of vertical force and EMG should be added to the results of dynamometric data. The analyses of kinemetric data and a multiple statistical analysis will be a work in progress.

RESULTS AND DISCUSSION:

Table 2 Selected Experimental Results of Jumps on Hard and Elastic Surfaces

		Elastic			Hard		
	Weight	CMJ height [cm]	DJ contact time [s]	DJ height [cm]	CMJ height [cm]	DJ contact time [s]	DJ height [cm]
all students							
M	68,0	37,84	0,279	41,37	34,89	0,340	36,17
SD	11,7	7,86	0,076	7,59	7,96	0,086	8,12
Men							
M	76,9	44,40	0,283	47,09	41,67	0,343	42,17
SD	10,4	6,65	0,079	6,70	6,11	0,091	7,80
Women							
M	61,0	32,93	0,276	36,94	29,97	0,34	31,52
SD	7,0	4,31	0,073	4,78	4,70	0,08	4,54

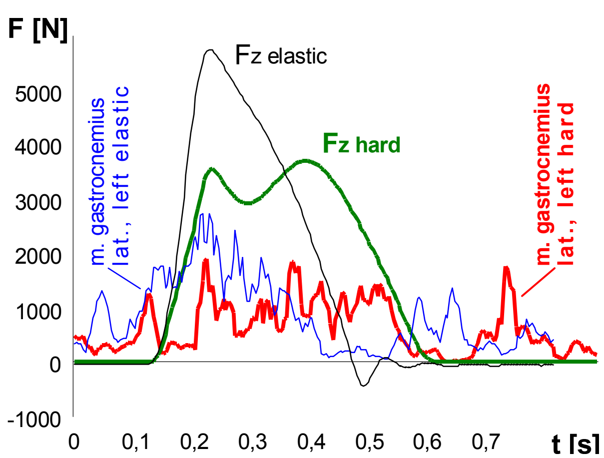

Figure 3 – Vertical force curve and EMG.

All differences between the parameters of the counter movement and drop jumps on hard and elastic surfaces (table 2) are significant ($p < 0.01$). On the elastic surface the jumps were higher. The contact time of the drop jumps was shorter.

The analyses of the ground reaction forces and EMG activities had similar results. The example of one subject on the elastic surface (figure 3) showed that the ground reaction force in vertical direction is steeper and the force peak is higher as well as the activity of m. gastrocnemius is more powerful.

CONCLUSIONS: The reason of this investigation was the wide variety of take-off movements in the several disciplines of sports. Analyses of some take-off movements in gymnastics, diving and figure skating proved that considerable differences exist (table 1). An experiment with sport students confirmed that hard and elastic surfaces influenced the performance and results of counter movement and drop jumps. In the present study the elastic surface decreased the contact time and increased the height of flight. The characteristics of the vertical force component were also changed. A described analysis of EMG activities showed similar results. The hypothesis of changes of important take-off parameters could be confirmed. Though, the type of muscular activity was a stretch shortening cycle on the used elastic surface (with the measured characteristics of the elastic swing floor). Consequently, the second hypothesis of a tension shortening cycle in drop jumps on the elastic swing floor could not be confirmed. It seems that the energy of the running approach velocity (or acrobatic elements) and the elasticity of surface influence the muscular activity. The phenomena of adaptation for the several conditions should be investigated in future.

REFERENCES:

Bobbert, M. F., MacKay, M., Schinkelshoek, D., Huijing, P. A., & Ingen Schenau, G. J. van (1986). A biomechanical analysis of drop and counter movement jumps. *European Journal of Applied Physiology*, 54, 566-573.

Bobbert, M. F., Huijing, P. A., & Ingen Schenau, G. J. van (1987). Drop jumping: I. The influence of jumping technique on the biomechanics of jumping. *Medicine and Science in Sports and Exercise*, 19, 332-338.

Frick, U., Schmidtbleicher, D., & Wörn, C. (1991). Vergleich biomechanischer Meßverfahren zur Bestimmung der Sprunghöhe bei Vertikalsprüngen (Comparison of biomechanical measuring methods for the evaluation of jumping height in vertical jumps). *Leistungssport*, 20(2), 48-53.

Härting, B., Zschocke, M. Alvermann, F., Wecker, U. & Schattke, U. (1982). Plattform zur Messung mehrerer orthogonaler Kraftkomponenten (Platform for measurement of orthogonal force components). Berlin: *Amt für Erfindungs- und Patentwesen*, Patentschrift 209519.

Hatze, H. (1998). Validity and Reliability of Methods for Testing Vertical Jumping Performance. *Journal of Applied Biomechanics*, 14(2), 127-140.

Hochmuth, G. (1967). *Biomechanik sportlicher Bewegungen* (Biomechanics of sports movements). Berlin: Sportverlag.

Kibele A.(1998). Possibilities and Limitations in the Biomechanical Analysis of Countermovement Jumps: A Methodological Study. *Journal of Applied Biomechanics*, 14(1), 105-125.

Knoll, K. (1999). *Entwicklung von biomechanischen Messplätzen und Optimierung der Sporttechnik im Kunstturnen* (Development of biomechanical measuring units and optimization of sports technique in gymnastics). Köln: Sport und Buch Strauss GmbH.

Krug, J. (1997). Muskulär-antriebseitige und informatorische Anforderungen bei Absprüngen und Flugbewegungen in akrobatischen Sportarten (Muscular and motor learning demands of take-off and flight movements). Zeitschrift für Angewandte Trainingswissenschaft, 4(2), 104 - 112.

Krug, J.; Knoll, K.; Köthe, T.; Zocher, H.-D. (1998): Running approach velocity and energy transformation in difficult vaults in gymnastics. Riehle, H.-J.; Vieten, M. M. (Eds.). *ISBS`98 Proceedings*, 160-163. - Konstanz.

Perlt, B. (1996). *Software for jumping movements on the dynamometric platform Type FKS-Leipzig.* Unpublished manuscript, Institute for Applied Training Science, Leipzig.

Virmavirta, M., Avela, J., & Komi, P. V. (1995). A comparison of different methods to determine the take-off velocity in vertical jump. In *Book of Abstracts from the XVth Congress of the International Society of Biomechanics*, June 2-6, Jyväskylä, 972-973.