

**PLANTAR PRESSURE DISTRIBUTION PATTERNS USED AS BIOFEEDBACK INFORMATION IMPROVE TECHNICAL TRAINING AND PERFORMANCE IN IN-LINE SPEED-SKATING**

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**INTRODUCTION**

In-line speed-skating (ISS) is a rather new competitive discipline with biomechanical characteristics similar to ice speed-skating (3,4). In both disciplines knowledge and feedback of push-off mechanics appear essential for performance optimization (1,2). Therefore, the goal of the study was to evaluate whether plantar pressure distribution patterns are useful as biofeedback information to develop exercises for technical training that are beneficial for performance optimization in ISS.

**METHODS**

The study consisted of two parts. **Part 1:** Foot pressure distribution (Novel-Pedar, 50 Hz) was assessed for eight elite in-line speed skaters (age: 28±5 years, weight: 72±4 kg) skating 1000 m at 35 km/h behind a car on a smooth road track. All athletes skated the road track four times with different push-off conditions in randomized order: normal technique (N), focused on normal technique (F), push-off with the forefoot/toes (T) and push-off with the heel (H). For each condition, five consecutive steps were analyzed yielding contact time (CT), peak pressure (PP), maximum force (MF) and force-time-integrals (FTI) for 10 anatomical regions. Furthermore, all subjects completed a questionnaire about their experience and sensation concerning push-off mechanics for the different conditions. Pressure distribution patterns and the results of the questionnaire were used to extract main characteristics of push-off dynamics in elite ISS and a training program with specific push-off exercises was developed accordingly. **Part 2:** The developed program was evaluated in a 6 week trial of technical training with 69 recreational in-line speed-skaters, randomly separated in a training group (TG; n=39; age 37±10 years, weight 70±12 kg) and a control group (CG; n=39; age 38±9 years, weight 67±10 kg). Technical training volume was similar for both groups (once a week, 105 min) with the major focus on basic technical aspects of the ISS technique. While CG focused only on basic technical drills, TG additionally used the specific push-off exercises. The

effect on skating performance was evaluated by a 200 m sprint test before (PRE) and after (POST) the 6 week program.

**RESULTS AND DISCUSSION**

Table 1 shows the PP-values of the elite skaters. The plantar pressure values indicated that the major characteristics during push-off are a well-distributed load between heel and medial forefoot and a push-off with pronounced heel impulse. This specific pressure distribution pattern is only altered by the condition push-off with toes, which is further mentioned in the questionnaire as most ineffective and "unusual". The results had shown that for technical training in Part 2 of the study specific exercises for plantar sensation during skating and for pronounced sideways push-off with high-heel impulse had to be used.

The results of the 200m sprint test yielded a significant improvement for TG (pre: 35.1±4.5 s; post 33.9±4.0 s, p=0.0005) and no changes for CG (pre: 38.9±7.0 s; post: 39.1±6.3 s, n.s.), underlining the positive effect of the developed technical training program on skating performance.

**CONCLUSIONS**

Plantar pressure distribution patterns yield useful biofeedback information for coaches and athletes and may help to improve technical training programs and performance in ISS.

**ACKNOWLEDGEMENT**

Supported by the BISP (Bundesinstitut für Sportwissenschaft; VF 0407/06/16/2002-2003).

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**Table 1:** Peak Pressure (PP, n=8) of 10 plantar regions of the foot at 4 push-off conditions. „\*\*“ marks a significant difference between conditions (ANOVA), „<“ and „>“ a trend (p<0.10) between conditions normal (N), focused (F), toes (T) and heel (H). Further abbreviations: med.= medial, lat.= lateral, cent.= central, n.s.= non-significant

Peak Pressure [N/cm <sup>2</sup> ]	Push-off conditions				Differences between conditions
	normal (N)	focused(F)	toes (T)	heel (H)	
Med. Heel	21,4±6,8	22,5±6,9	15,4±7,7	23,8±6,5	trend (T<H)
Lat. heel *	21,1±7,3	21,5±6,1	15,2±7,3	23,4±6,3	trend (T<H)
Med. Midfoot	8,0±4,7	8,0±4,4	8,2±5,2	8±4,3	n.s.
Lat. Midfoot†	5,9±2,7	6,1±2,2	6,3±1,8	6,1±2,4	n.s.
Med. forefoot	18,0±7,9	17,7±7,9	19,0±9,3	16,8±7,8	n.s.
Cent. Forefoot	7,7±2,9	8,2±3,0	10,9±5,3	7,7±3,4	n.s.
Lat. Forefoot	7,8±2,0	7,1±2,0	10,9±3,2	7,0±3,9	trend (T>F; T>H).
Hallux	19,3±14,9	16,9±12,1	19,4±9,0	13,0±8,5	n.s.
Second toe	7,8±2,0	7,1±2,0	10,9±3,2	7,0±3,9	n.s.
Lat. Toes	8,7±3,5	9±2,7	11,3±4,7	7,4±3,6	n.s.