BIOMECHANICAL ANALYSIS OF THE DYNAMICS OF SKATING (SKATING 1-2)

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INTRODUCTION: Biomechanical data (curves and values) on skating technique are necessary for effective technique training. 1995-1997 kinematographic 3D-analyses of international top class athletes were made during uphill skating. A kinematic description of skating technique, as well as of technical reserves of top German athletes was obtained (Herrmann/Clauß, 1997). The specific dynamic reasons for the kinematic appearance were the subject of continued analyses.
It was also aimed to collect information about measuring technical requirements of specific sensors and their attachment to the specific ski and pole. Corresponding results published so far are insufficient and affected by problems.

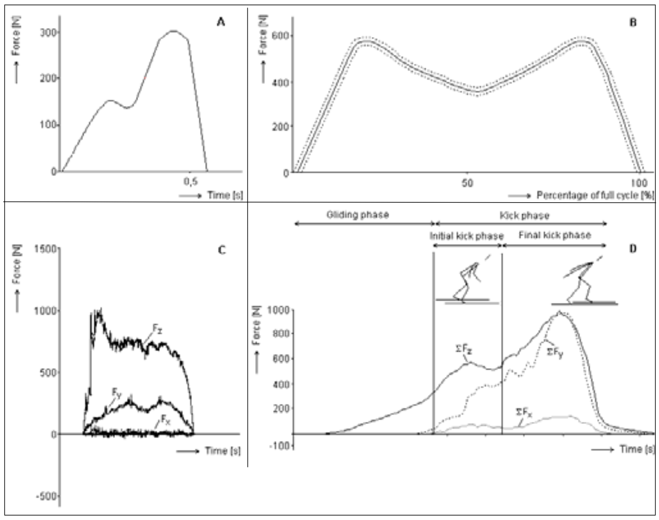

FIGURE 1: RESULTS FOR DYNAMIC OF SKATING
A - GROßMANN in NITZSCHE (1998)
B - LINDINGER/MÜLLER (1995)
C - NEUMEIER (1997)
D - LEPPÄVUORI (1993)

GROßMANN in NITZSCHE (1998) did not specify what component of force was registered (see Figure 1A). His measured values for force are definitely too low.
LINDIGER/MÜLLER (1995) registered only the component of force directed vertically to the ski (see Figure 1B). These measuring results do not provide information about the amounts of the system-accelerating propulsion impulses.
Nor do the measurements of the force components by NEUMEIER (1997), (see Figure 1C) permit conclusions about the dimensions of the system-accelerating propulsion impulses. Beyond that, the amount of the F_x component is likewise not expected to be in the range of 0 Newton.
The three force components measured by LEPPÄVUORI (1993) do not indicate an expected braking impulse in the F_x-t function during the gliding phase. That means that the athlete would only accelerate in the sequence of cycles (see Figure 1D).

METHODS: In the framework of a study dynamic-kinematic 3D-measurements were made. Three experienced female and one male skiers moved over a field of five coupled 3D force measuring platforms (0.8m x 0.8m each) using roller skis, inline skates and specific skis. Evaluation was carried out using a Peak-Motus system with a 32-channel-analog board. For the measurements with the specific skis the measuring platform and a surrounding area (ca. 3m x 10m) were covered with a foil. A gliding expedient was spread on the foil so that four skating cycles could be realized. In addition, a synchronous video recording of the moving cycles was made with four cameras (50 Hz) and two cameras (250 Hz).

RESULTS:

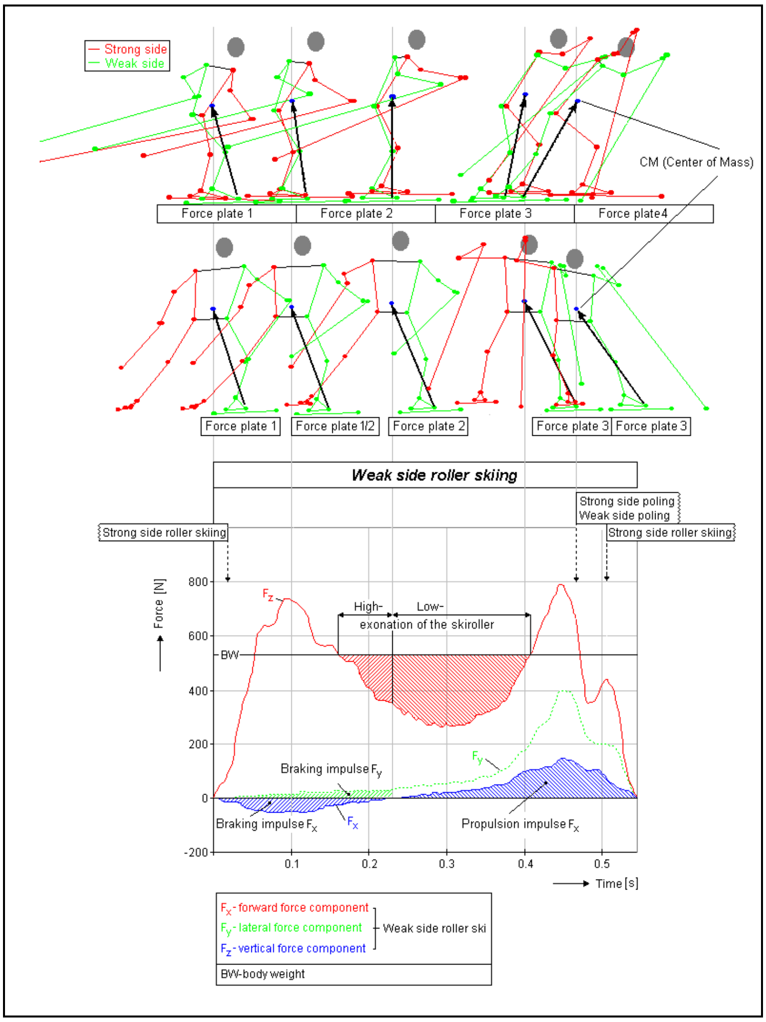

FIGURE 2: DYNAMIC-KINEMATIC DIAGRAM OF SKATING ON ROLLER SKIS (LEG/SKI WEAK SIDE)

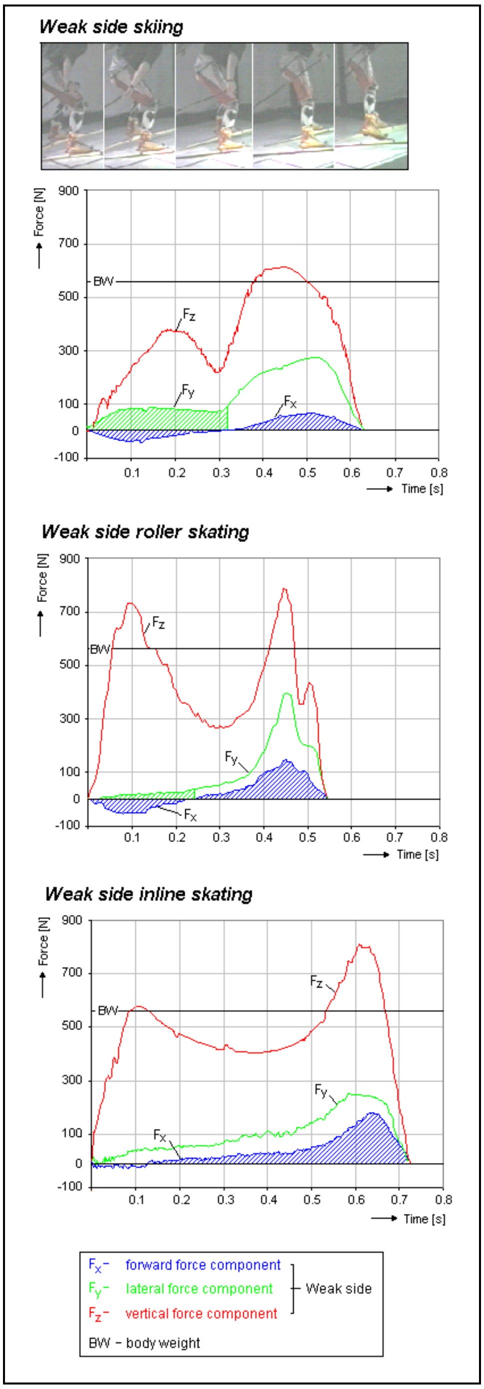

FIGURE 3: 3D-DYNAMIC-KINEMATICAL DIAGRAMS OF SKATING (WEAK SIDE) WITH DIFFERENT SPORTS EQUIPMENT

I. Ground reaction forces of leg/ski in three dimensions during the gliding and kick-off phase could be combined with the record of the movement and corresponding biomechanical data. For the first time impulses of the braking forces during the gliding phase could be measured. It could be shown how their temporal appearance and amount during the kick-off phase can be influenced by a reasonable movement (see Figure). As briefly discussed, the results and findings are contrary to earlier studies like GROßMANN in NITZSCHE (1998), LINDINGER/MÜLLER (1995), NEUMEIER (1997) or to details found by LEPPÄVUORI (1993).

II. There is a functional inter-dependence between the amounts of the accelerating force impulses of the F_x and F_y components and the tread out angle of the ski. Small tread out angles of the ski were in connection with proportionately bigger accelerating force impulses of the F_y component. As theoretically expected, the vertical movement of the upper part of the body could be observed in the characteristics of the F_z-t function. At the beginning of poling the amounts of all three components of force clearly decreased (see Figure 2).

III. The supporting phases (pure gliding and propulsive phases) were the shortest during roller skating and significantly the longest during inline skating. The biggest braking impulses of the F_x and F_y components in the gliding phase were measured during skating with special skis in comparison with skating on roller and inline skater (see Figure 3). In approximation the basic characteristic of F-t-functions was equivalent in all three types of sports equipment.

IV. The amounts of the force components came for F_z 0 N to 1 kN, for F_y of 0 N to 500 N and for F_x of -150 N to +200 N. The upper limit of frequency for the courses of the basic signals was 65 Hz.

CONCLUSIONS:

- The efficiency of the ski position during the gliding phase of skating (plane) can be derived from the relation of brake impulses for F_x and F_y.
- The simultaneous ski- and pole kick obviously leads to a negative influence of the propulsion impulse achieved by leg/ski.
- In case of furnishing sure evidence for such a recognition in future it would have consequences regarding the temporal coordination of leg/ski and pole kick.
- The insights on 3D-ground reaction forces related to athletes' motion are to be used for diagnostic systems in the future.
- The fixation of suitable 3D-force sensors combined with position sensors on the sport equipment (ski/pole) may help to collect equivalent data (curves and values) under field conditions.

REFERENCES:

Grigor'ev, V. A., Fedodkina, O. I. (1986). Effektivnost' kon'kogo choda v lyznom sporte s tocki zwenija zatrat mechaniceskoj energii. *Theorija i praktika fiz. kul't*. **3**, 8-9.

Herrmann, H., Clauß. M. (1997). Biomechanische Untersuchungen zum Realisierungsstand der Skatingtechnik 1-2 am Anstieg durch Weltspitzen-athleten/-innen im Biathlon. *Leipziger sportwiss. Beiträge. XXVIII* **2**.

Komi, P. V. (1987). Force Measurement during Cross-Country Skiing. *International Journal of Sport Biomechanics* **3**, 370-381.

Leppävuori, A. et. al. (1993). A New Method of Measuring 3D-Ground Reaction Forces under the Ski. *Journal of Applied Biomechanics* **9**, 319-328.

Lindinger, S., Müller, E. (1995). Biomechanische Beschreibung ausgewählter moderner Skatingtechniken im Skilanglauf. *Leistungssport* **15**, 2.

Neumeier, A. (1997). Untersuchungen zu dynamischen Einflußgrößen auf die Laufgeschwindigkeit im Skilanglauf. Forschungsprojekt. BISP.

Nitzsche, K. et. al. (1998). Biathlon. Wiesbaden: Limpert-Verlag.

Smith, G. A. et. al. (1989). Analysis of V1 Skating Technique of Olympic Cross Country Skiers. *International Journal of Sport Biomechanics* **5**, 185-207.

Smith, G. A. (1992). Biomechanical Analysis of Cross-Country Skiing Techniques. *Medicine and Science in Sports and Exercise* **4**, 1015-1022.