

# BIOMECHANICAL SKATING TECHNIQUE ANALYSIS IN BIATHLON

Hartmut Hermann and Martina Clauß  
University of Leipzig, Working group biomechanics, Germany

The paper describes examples from a biomechanical research project which is carried out in co-operation between the German Skiing Association/national team in biathlon and the University of Leipzig. The aims of the study were a) to develop a practical procedure to verify dynamic and kinematic skating technique features under typical conditions for the sport, b) to determine valid skating technique characteristics and c) to develop an feedback procedure which can be used in training sessions. The findings have been applied in training during the preparatory phase for the competition season 1999/2000. Biomechanically the study focussed on the determination of an effective temporal co-ordination of system propulsion impulses being generated by arms/poles and legs/skis.

**KEY WORDS:** skating technique, procedure for technique analysis, sports technical features, biathlon

**INTRODUCTION:** For international top performances in biathlon the skiing result is a limiting factor besides the performance in shooting.

The skiing result is significantly influenced by the skiing technique which the athlete performs on the plain track and when skiing uphill and downhill.

The initial purpose of the study was to develop and practically apply reliable procedures of skiing technique analyses guaranteeing an individual use of the sport apparatus almost without affecting the sports typical movement pattern and to investigate into valid skiing technique features for a comparison of the actual technique with a given model during the parameter based training of skiing technique.

The second purpose were dynamic and goniometric measurements (especially concerning leg positioning and ski push off features) when skating. These data should be processed in such a way that they could represent feedback information during training sessions for coaches and athletes.

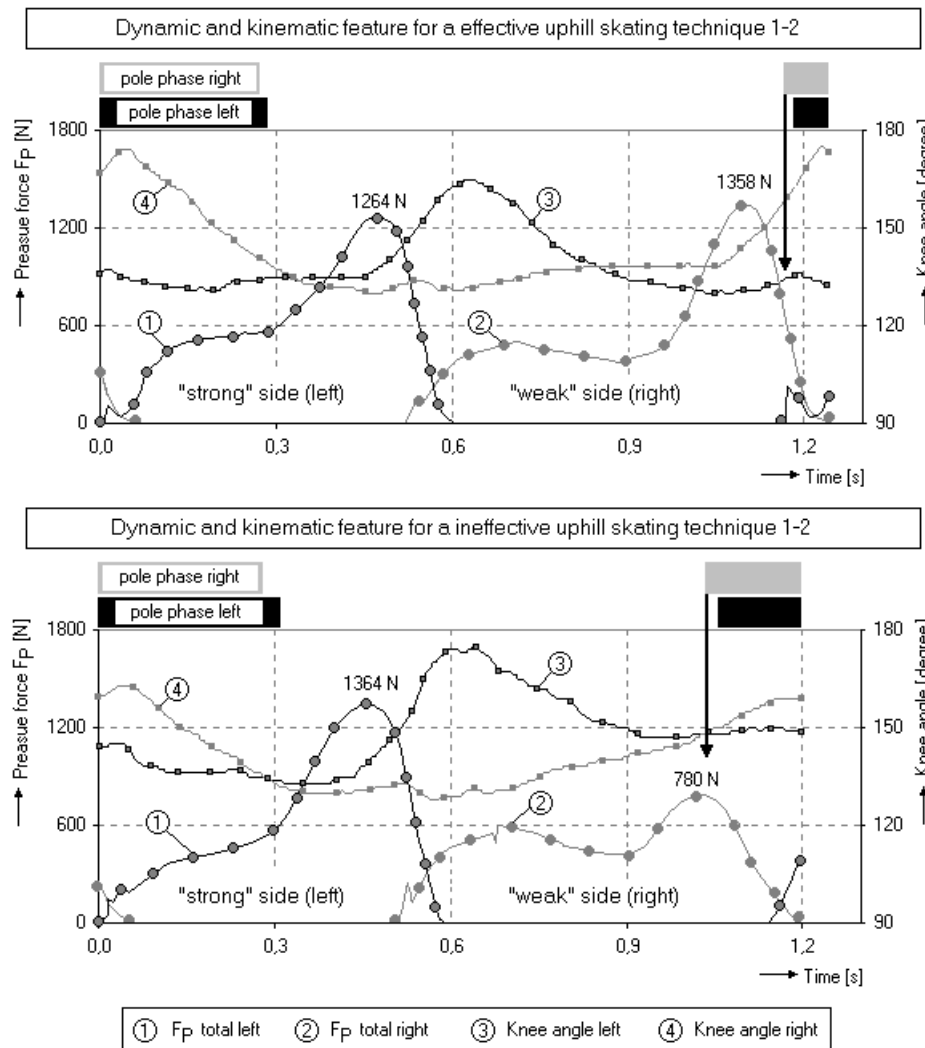
**METHODS:** The members of the female national biathlon team were analysed several times during the preparatory phase for the competition season 1999/2000. The measurements concentrated on the leg push off forces when skiing uphill, on a plain track and downhill (measured by 24 pad-pressure force soles, 250 Hz frequency per pad signal by PAROMED), on the knee angle (measured by biaxial goniometers XM 110 by PENNY and GILES) as well as on synchronous kinematic movement parameters (kinematic parameters from 3D-video analyses calculated from PEAK-Motus-system). The results were immediately evaluated after the measurement using a special software solution ("VIDEO-COMBI" based on HPVEE 5.01). The evaluation was concentrated on a comparison with technical skating models which were developed on the basis of our own theoretical considerations and on empirical data (compare Bilodaev and Bouly, 1992; Smith, 1992; Leppävuori et al., 1993; Schwirtz, 1994; Lindinger and Müller, 1995; Clauß, 1998; Herrmann and Clauß, 1998; Herrmann and Clauß, 1999).

**RESULTS AND DISCUSSION:** One example of our findings in these analytical studies are valid uphill skating technique features. For this paper we selected some examples which we want to describe below:

The total pressure force-time course in succeeding movement cycles (at least four cycles) is an expression for the efficiency of the movement sequence to generate acceleration forces (compare figure 1) of the system athlete-sport apparatus. The temporal position and the amount of the maximum knee angle velocity (turning point in the knee angle-time-function) shows a correlation with the amounts of the reactively measured muscular pressure force impulse.

Asynchronous push off phases of leg/ski and arm/pole show a significant relation to the

values of leg pressure force impulse and the peak values in the pressure force-time-courses (compare figure 1).



**Figure 4 - Examples of analytic results for dynamic and kinematic uphill skating technique features 1-2.**

Female athletes with almost synchronous leg/ski and arm/pole push off phases (especially often found on the “weak” side of skating technique 1-2) permanently generated significantly lower leg push off force values in comparison to the values when skating without poles. Female athletes mastering an asynchronous arm/pole and leg/ski technique comparable push off force values on both sides performed in both variants (skating with and without poles).

The course of the centre of pressure of the foot above the ski surface is a technical skiing feature for the relation between gliding and push off phase with leg/ski being on the snow (compare figure 2). Significant spatial changes of the centre of pressure in relation to the longitudinal axis of the ski immediately after the impact of the ski characterise an ineffective ski impact and an ineffective gliding phase of the ski (with the ski being in an angle to the surface). Great spatial deviations during the push off phase characterise push offs with leg/ski from an almost “solid “ support. Such a push off correlates with greater variations of system velocity in horizontal direction. These variations again are ineffective in cyclic movements from an energetic point of view.

The push off-time-courses for the heel, the metatarsus and the ball of the foot (compare figure 3) show a high significance in efficiency of the performed.

- a) ski application phase with the aspects of a perpendicular position of the athlete's body above the ski, the active forward propulsion of the ski into the snow.
- b) ski push off phase with the aspect of an "explosive" leg push off of the gliding ski starting in the ball of the foot.

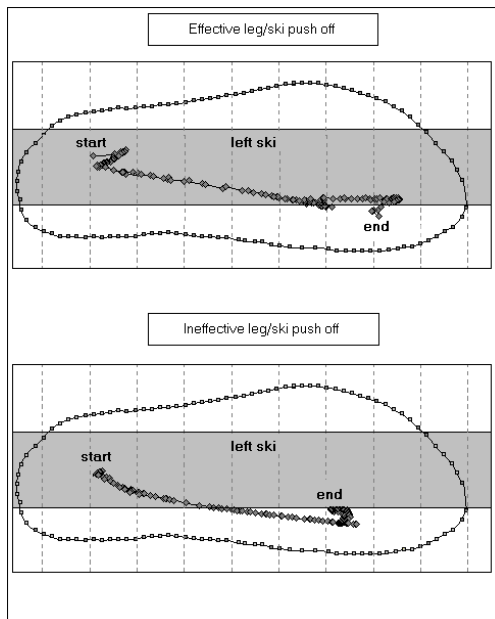


Figure 4 - Example of a uphill skating technique 1-2 (centre of foot pressure on ski surface).

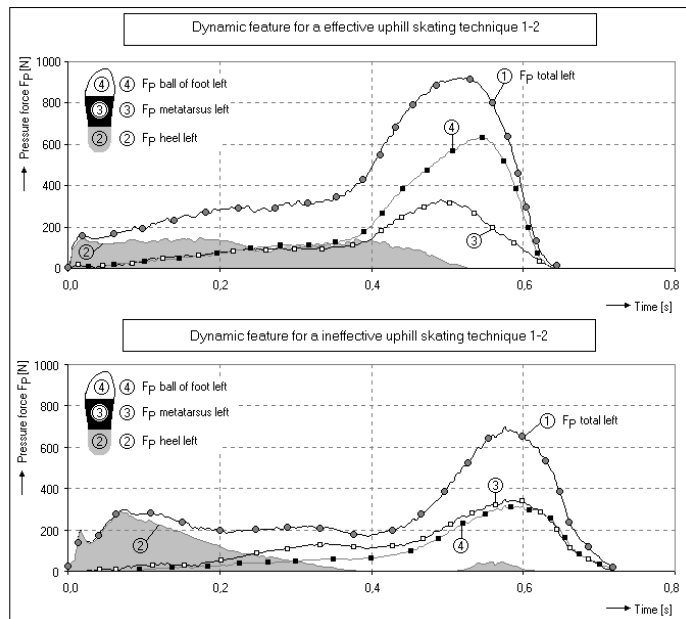
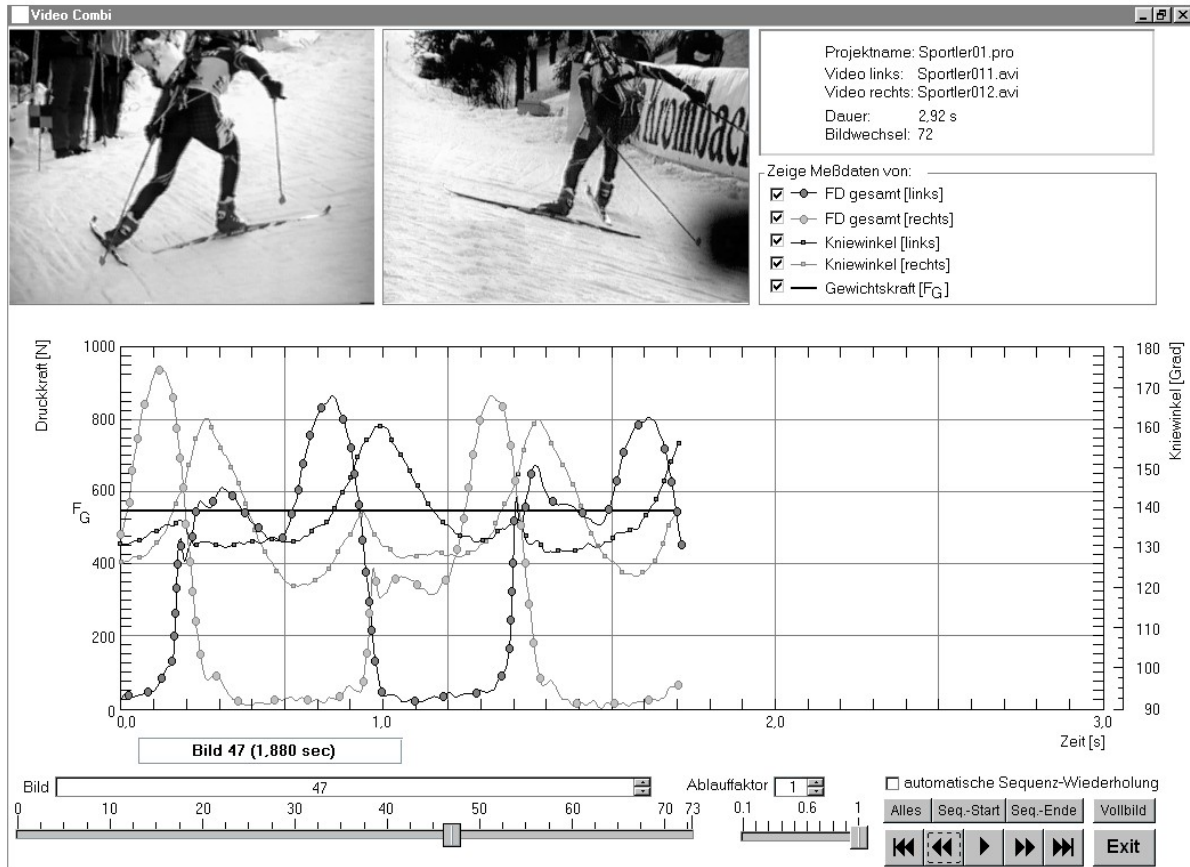


Figure 4 - Example for uphill skating technique 1-2 (push off force-time-course for heel-metatarsus-ball of foot region).

**CONCLUSIONS:** The developed objectivation procedures and skating technique features as well as their application and the methodological evaluation of data have proved successful during training sessions of the German Skiing Association/Biathlon. The findings agree with previous findings (compare Herrmann and Clauß, 1999) that as a result of body extension (but first of all of leg extension when skating) under the conditions of an open kinematic chain (e.g. when skating pole push off phase has not yet started) greater values can be generated for leg push off force impulses compared to the values found for a synchronous ski push off and arm/pole push off effect (closed kinematic chain). But for the first time such findings were based on a study under conditions which are typical for biathlon.

So we can conclude that because of synchronous actions of leg/ski push off and arm/pole push off the kinematic chain feet-legs-trunk is extended as a consequence of the arm/pole push off actions. These extensions correlate with lower values for forces/momenta by leg extensors (e.g. by corresponding muscle sling effects too). Thus a synchronous push off action results in lower total force impulses in movement direction.



**Figure 4 - Feedback system of an event for monitoring movements (real monitor-picture).**

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