# A LONGITUDINAL STUDY OF THE TAKE-OFF AND TRANSITION PHASE IN SKI-JUMPING AT INTERSPORTTOURNEE INNSBRUCK 1992-1994

FRANTISEK VAVERKA, MIROSLAV JANURA

LABORATORY OF HUMAN MOVEMENT STUDIES. PALACKY UNIVERSITY. OLOMOUC. CZECH REPUBLIC

## INTRODUCTION

The length of jump - as a final result of the ski-jumping - is determined by a very long and complicated chain of factors affecting different phases of the jump. In principle the factors can be divided into external factors (construction of the jumping hill, surface - ceramic, snow. mat, climatic conditions, physical quality of the ski and dress e.t.c.) and internal factors (the structure of movement, psychological, and somatic abilities and preconditions). The final model of ski-jumping is the result of the interaction between the all influences.

The change in the flight position during the last 2-3 years so-called "V" style, may be the significant impulse for changes in the technique in ski-jumping in the take-off and transition phase. The above-mentioned suggestions were the impulses for solving the ski-jumping problem over a longer time period. This paper gives information on the longitudinal analyses of the ski-jumping technique and presents some partial findings from this project.

## PROBLEM

Some papers exist which solve the problem of kinematic analyses in ski-jumping (Komi et al.. 1974, Baumann, 1979, Vaverka, 1987, Hubbard, 1989, and others). These papers present a unique view on the technique of different phases of ski-jumping relating to time, jumping hill, and the set of analyzed athletes. In the last 2-3 years the flight position of jumpers has been changed to "V" style. The beginning of the flight phase depends on the quality of the take-off and transition phase. One of the most important questions is whether the "V" style of flight influences the pattern of the take-off and transition phase.

The above mentioned problem and the desire to know how today's model of ski-jumping looks were the starting points for the conception of the project of longitudinal analyses of ski-jumping. The long-term observation of the ski-jumping technique must be solved by stabilization as soon as possible of the most factors affecting the ski-jump (e.g. one jumping hill, the set of top athletes, the same time of season). The best event for this type of project is the Intersporttournee which takes place in Innsbruck where there are very suitable terrain conditions for taping the take-off and transition phase and this competition fulfilled all the conditions mentioned above (the event takes place each year on January 4th and the best athletes of the world compare).

We focused on two problems in the presented study:

-What is the present model of the take-off and transition phase like ?

-Are there any changes in the technique of the take-off and transition phase in the last three years ?

## METHODS

During the last three years 1992. 1993, and 1994 the take-off and transition phase has been taped at the same camera position in the terrain. By using the programme package of the Kinematic analyses of the ski-jumping, developed at our Laboratory, the 2-D analyses were realized for both observed phases. The take-off phase was analyzed from 5-6 m before and 2 m after the take-off edge and the transition was analyzed from the edge to 6-7 m after the take-off edge. In Fig. 1 are expressed in the graphical form the analyzed parameters (take-off: 8 angles and 3 velocity parameters, transition: 11 angles and 3 velocity parameters). The length of jump and approach velocity are involved in the statistic analyses exept the analyzed parameters. In the present paper we are elaborating only on the parameters evaluated on the edge for the take-off phase and in distance 5.6 m after the edge for the transition phase. The analyses were always provided for the set of athletes participating in the 1st race round (the set marked ALL, n = 51-60). Three sets of athletes were selected from these basic sets according to the length of jump (n = 11-15): B - best, jumpers reached the longest length of jump, M - middle, average jumpers, and L - low, the athletes with the shortest length of jump. Four matrices of data were defined for each analyzed phase, e.g. during three years 24 data matrices. With regards to the formulated questions the differences between the selected groups in each competition and between the same sets in different years were tested. For the statistical elaboration of tested data the statistic package STATGRAPHICS was used using the PC/AT computer. The procedure followed was: Basic statistical characteristics, One-way analysis of variance, Multiple range of analysis (Tuckey), Box and whiskers plots, Correlation and Factor analysis.

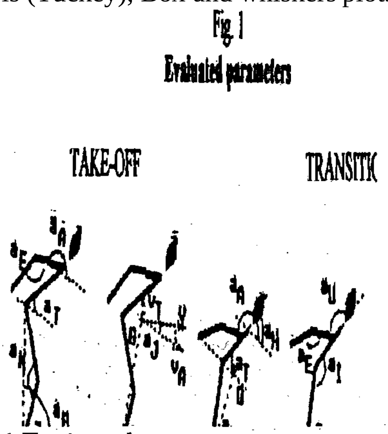


Fig. 1 Evaluated parameters

RESULTS AND DISCUSSION

The model of observed phases of ski-jumping is given by the statistical characteristics of selected 'sets. Only a few significant differences have been found between sets of athletes in both observed phases. The main reason is in very large selected sets variances than in most cases the standard deviations of selected sets were almost equal to basic set's standard of deviation. In Table 1 is given an example of one matrix of the statistical data from the competition in 1994. We can see the statistical significant differences, exept the length of jump, from the angles describing the lean of the body forward ($\alpha R$, $\alpha G$) and from the measured velocities. The velocity VT is comparable with this one published in the study Jost (1993). The best jumpers are in the advanced phase of rotation and reach a higher level of take-off velocities. The tendency of the progressive forward lean of the body was also confirmed by the values of $\alpha C$.

In the transition the same tendencies were found with the minimum of statistically significant differences between observed sets. A minimum differences were found in the position of the body, but statistically significant differences were found in the velocities. The set of best athletes has the highest horizontal velocity and the lowest vertical velocity (dropping of the flight curve).

The change in the period from 1992 to 1994 can be characterized by very interesting tendencies in spite of the fact that the number of statistically significant differences is still very low. Our most important finding is that the differences have been found only in the set of the best athletes.

In the take-off phase the take-off seems to **finish** before the takeoff edge (there is a slight tendency towards an earlier take-off finish). According to the study Vaverka et al. **(1992)** an accurate take-off is characterized by the angle **αK = 138°±3°** in the position on the take-off edge. We have found the angles **αK** in the set of best jumpers from 1992 to 1994: **140°, 145°, 144°** . These findings closely relate to the progressive lean forward of the center of gravity (angles αR from 1992 to 1994: **89.7°, 87.5°,** 87.9').

Table 1. Kinematic analysis of the take-off **Intersporttournee INNSBRUCK** 1994, K120

| Parameter | All. n=51 Mean | SD | B, n=13 Mean | SD | M, n=15 Mean | SD | L, n=15 Mean | SD | Differences B-M | B-L | M-L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LJ | 92.70 | 8.46 | 102.77 | 4.43 | 91.70 | 2.19 | 83.20 | 3.60 | * | * | |
| AV | 88.72 | 0.44 | 88.78 | 0.40 | 88.81 | 0.43 | 88.48 | 0.49 | | | |
| αC | 70.81 | 3.77 | 69.81 | 3.30 | 71.36 | 3.40 | 71.65 | 4.90 | | | |
| αK | 141.73 | 7.28 | 143.54 | 5.80 | 141.90 | 8.10 | 139.29 | 7.20 | | | |
| αT | 24.37 | 5.29 | 24.42 | 6.10 | 24.43 | 4.50 | 23.17 | 5.00 | | | |
| αA | 182.30 | 10.32 | 181.84 | 9.60 | 184.30 | 10.00 | 179.66 | 11.30 | | | |
| αE | 158.79 | 10.00 | 159.19 | 8.90 | 154.59 | 10.20 | 159.47 | 9.60 | | | |
| αR | 89.75 | 3.85 | 87.87 | 3.00 | 90.48 | 3.10 | 91.67 | 3.80 | | * | |
| αG | 74.71 | 2.58 | 73.44 | 2.30 | 75.13 | 2.00 | 76.07 | 2.80 | | * | |
| αJ | 5.62 | 0.76 | 5.69 | 0.70 | 5.38 | 1.00 | 5.65 | 0.50 | | | |
| V | 25.85 | 0.19 | 25.91 | 0.15 | 25.89 | 0.18 | 25.72 | 0.20 | | * | |
| Va | 25.72 | 0.19 | 25.78 | 0.15 | 25.77 | 0.17 | 25.59 | 0.20 | | * | |
| Vt | 2.53 | 0.34 | 2.57 | 0.32 | 2.43 | 0.48 | 2.53 | 0.25 | | | |

* $p<0.05$

In the transition phase similarly to the take-off phase a change in the faster transition of the athletes in the flight position has been found. The jumpers are in the progressive phase of rotation in years 1993 and 1994 in comparison with the year 1992. This idea is supported above all by the change of the lean of the body describing by the angles àG (1992-1994: **59.1°, 55.2°,** 56.2' ), angle of head **αH (27.5°,** 26.6'. 23.4' ), and angle of the lower extremity **αL** (71.3'. **67.1°,** 68.2'). The lowering of the angle **αV** (declination of the flight curve from the horizontal line) seems very interesting **(αV:** 7.4, 6.6, 5.6 ) and this trend indicated the raising of the flight curve by just 5.6 m after take-off edge.

Research findings of the take-off and transition phase indicate that in the observed three year period the tendencies of the changes in the technique observed phases have been found. The changes are typically found after the year 1993 when the "V" style of flight was used by most athletes.

CONCLUSIONS

- Statistical analyses confirmed the great interindividual variability in the take-off and transition phase. Parameters of the set of top jumpers are closest to the general model of observed phases.
- The best athletes differ from the average **and** low-level athletes in higher take-off and transition velocity. progressive phase of forward rotation in take-off and transition, and higher course of the flight curve in transition.
- Significant changes have been found in the conception of the take-off and transition during the years **1992-1994.** The main tendency can be defined as the effort to finish take-off slightly earlier before the take-off edge and accelerate the transition of the

**body to the forward rotation. The change has been recognized since 1993 when the "V" style started to dominate in the flight situation.**

**- Based on our findings it can be concluded, that the new relevant information can be taken only by analyses of the top athletes.**

REFERENCES


Bauman, W. (1979). The biomechanical study of ski-jumping. In: Proceedings of International Symposium on Science in Skiing, Japan, 70-95.

Hubbard, M., Hibbard, R.L., Yeadon, M.R, and Komor, A, (1989). A multisegment dynamic model of ski-jumping. International Journal of Sport Biomechanics, 5,259-274.

Jost, B. (1993). Performance succes in ski-jumping related to vertical take-off speed. In: J. Hamil, T.R. Derrick. E.H. Elliot (Eds.). Proceedings of the Biomechanics in Sports XI. University of Massachusetts, 145-147.

Komi, P.V., Nelson, R.C., and Puli, M. (1974). Biomechanics of Ski Jumping. Studies in Sport, Physical Education and Health (Vol. 5), University of Jyväskylä.

Vaverka, F. (1987). . Biomechanika skoku na lyzích (Biomechanics of Ski-jumping). Monograph, UP Olomouc, 235 pp.

Vaverka, F., Janura, M. , Krskova, M., Elfmark, M., and Salinger, J. (1992). The accuracy of the ski-jumper's take-off. In: R. Rodano, G. Ferrigno, G. Santambrogio (Eds.). Proceedings of the International Society of Biomechanics in Sports X.
Milan, 319-322.

Vaverka, F., Elfmark, M., Janura, M., and Krskova, M. (1994). Kinematic Analysis of Ski-jumping. User's manual, UP Olomouc, 109 pp.