COMPARISON OF SOME KINEMATIC FLIGHT PARAMETERS OF SKI JUMPERS BETWEEN THE CLASSIC TECHNIQUE (1990) AND THE SO-CALLED "V" TECHNIQUE (1993) AT THE WORLD-CUP COMPETITION AT PLANICA (K 120 M)

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INTRODUCTION

The flight of a ski jumper is one of the most important phases of the ski jump which is performed in a specific inertial environment determined to a considerable extent by the aerodynamic parameters and the weight of the jumper-equipment system. Already from the very beginning of the development of the ski-jumping technique there have occurred constant modifications of the technique (1). The object and goal of this research has been to compare kinematic parameters of the flight between the old and the new technique in order to establish any essential changes in the posture of ski jumpers in the air in case of a modification of the flight technique. At the same time we also wanted to establish and compare the extent of interrelations between kinematic parameters of the flight defined in the one or the other technique by the length of the jump.

METHODOLOGY

The data for this research have been obtained in two parts. In the first part of our research we have included 30 ski jumpers taking part in the final of the World Cup on a 120m-ski-jumping hill at Planica on 24/3/1990: they performed two jumps in the classical technique (all variables defined in this competition are designated with the following code numbers: number 1 - first series and 2 - final series). The said two jumps were recorded by a high-speed film camera BOLEX. The second part of the measurements was camed out three years later, also on a sample of 30 best ski jumpers of the world taking part in the final series at the introductory competition for the World Cup camed out on a K120-m- ski-jumping hill at Planica (all variables defined in this series are designated with the number 3) on 12/12/1993. This jump performed in the new "V" technique was recorded by a video camera on the same location, that is at a distance of 60 m away from the edge of the take-off platform at an average slope of the landing area of 27 angular degrees. In-relation to this point, the cameras were positioned at a right angle and were 23 m away from the movement direction of the ski jumper. The flight curve was on average at the level of the camera.

For the requirements of this research, the following kinematic variables have been defined:

Angle between the legs and the trunk: ALFA - α
Angle between the chord connecting the ankle joint and the shoulder joint: BETA - β
Angle between the skies and the chord connecting the ankle joint and the shoulder joint: FI - ϕ
Angle between the trunk and the arms: GAMA - γ
Flight height: FLH
Length of the jump: JUMPL
Style grade: STYLEG

RESULTS

Table 1: Basic Statistical Parameters

Variable X	SD	MAX		MIN
ALFA1	164.0	6.46	180	151
ALFA2	164.5	5.93	178	153
ALFA3	161.5	5.36	173	151
BETA1	18.7	4.25	30	9
BETA2	19.7	4.29	30	11
BETA3	14.6	3.66	21	6
GAMA1	183.3	8.56	218	172
GAMA2	181.6	11.63	200	139
GAMA3	178.9	2.37	185	178
FI1	21.7	4.59	33	14
F12	22.1	4.58	36	15
F13	11.0	3.26	19	6
FLH1	5.2	0.97	6.6	2.7
FLH2	4.1	1.06	5.8	1.8
FLH3	3.5	0.52	4.5	2.4
JUMPL1	112.5	11.21	125	81
JUMPL2	100.0	8.50	121	79
JUMPL3	116.5	8.61	136	100
STYLEG1	48.7	4.47	54	33
STYLEG2	45.0	3.28	52	39
STYLEL3	53.8	2.93	58	45

Table 2. Regression Analysis of the Jump Length (in the table there are shown only the variables which from the aspect of statistical significance contribute to the explanation of the respective length of jumps)

Variable	r	Beta	T	Sig T
FLH1	0.56	0.36	2.41	0.02
FLH2	0.83	0.81	8.88	0.00
FLH3	0.54	0.62	4.18	0.00
ALFA1	-0.55	-0.39	-2.66	0.01
BETA1	-0.35	-0.29	-2.16	0.04
BETA2	-0.33	-0.29	-3.14	0.00
BETA3	-0.29	-0.40	-2.60	0.01
	Mult r	Rsq	Sig f	
First jump	0.73	0.53	0.00	
Second jump	0.88	0.77	0.00	
Third jump	0.70	0.49	0.00	

Legend:

r - coefficient of linear correlation
Beta - standardised beta values
T - T-coefficient
Sig T - statistical significance of the T-coefficient .
Mult r - coefficient of multiple correlation
Rsq - square of the multiple correlation coefficient
Sig f - statistical significance of the multiple correlation coefficient

Comparison of the average values of individual jumps indicates a marked difference between the kinematic parameters of the classical and new technique, expressed primarily in the inclination of a jumper towards the front (BETA) (in the new "V" technique, ski jumpers are moreinclined towards the front) and in the position of the skies during the flight (FI): in the new technique they follow more the posture of the body. In the old technique the skies were usually positioned slightly below the horizontal plane (3 angular degrees), while in the new one they positioned 3 angular degrees above the horizontal plane. On average, the ski jumpers were also slightly more bend in the hips in the new technique. the new technique allowed longer jumps. with the jumpers flying lower above the jumping hill. Longer jumps also accounted for significantly higher grades for the style.

DISCUSSION

The new technique of the flight of ski jumpers established in the season 1991/92 has confirmed its greater aerodynamic efficiency already as regards the results of the ski jumpers. By comparison of some kinematic parameters between the old-and the new technique we have found that in the new technique ski jumpers are more inclined towards the front during the flight and that they are more bent in the hips. At the same time, the skies are positioned closer to the chord formed by the body and slightly above the horizontal plane in the new technique. Such a position has with certainty also influenced the length of the jumps, i.e. the performance of the ski jumpers, which fact has been established by regression analysis of the performance of the ski jumpers in respect of the jump length (Table 2).

The greatest linear correlation with the jump length has shown the variable FLH1 (flight height). The ski jumpers who flew higher were in general more successful. Of course, the height of the flight at the point of observation of kinematic parameters was already a consequence of the effect of these parameters in the part of the flight before that observation point. Irrespective of that, tendencies of optimisation of aerodynamic moments of the acting forces can be established: they are shown in minimisation of air resistance in the vertical direction. These tendencies also bring about a favourable increase in aerodynamic lift (Vaverka, 1987), which above all in the best ski jumpers allows them to maintain high horizontal velocities of the flight and hence slower falling especially in the second part of the flight.

CONCLUSIONS

On a sample of 30 best ski jumpers, the participants of the World Cup final at Planica The comparison of the obtained results has shown that in the new technique ski jumpers are more inclined towards the front, that they form a smaller angle with the skies during the flight (viewed in the sagittal plane), that they are more bent in the hips and that they achieve considerably longer jumps at a lower height of the jump (observed somewhere in the middle of the flight). The length of the jump is, similarly as in the classical method, still to the greatest extent influenced by the flight height and the inclination of the ski jumper towards the front; however, a corresponding bent in the hips and suitable positioning of the skies in the air should also not be neglected.

in 1990 and the World Cup begin in the season 1993/94, we have analysed some kinematic characteristics in the phase of flight, and compared the differences between the old classical and the new "V" technique of ski jumping.

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