

DIFFERENCES IN SOME KINEMATIC FLIGHT PARAMETERS BETWEEN THE CLASSICAL AND THE NEW SO-CALLED "V" TECHNIQUE IN SKI JUMPING

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Abstract

On a sample of 30 best ski jumpers, the participants of the World Cup finals at Planica in 1990 and the World Cup start in the season 1993/94, we have analysed some kinematic characteristics in the phase of flight, and compared the differences between the classical and the new "V" technique of ski jumping.

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 skis 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 skis in the air should also not be neglected.

Key words: *ski, jumpers, kinematic flight characteristics, success*

Sažetak

RAZLIKE U NEKIM KINEMATIČKIM PARAMETRIMA LETA IZMEĐU KLASIČNE I NOVE TAKOZVANE 'V' TEHNIKE KOD SKIJAŠKIH SKOKOVA

Na uzorku od 30 najboljih skijaša skakača, sudionika završnice Svjetskog kupa na Planici 1990. i početka Svjetskog kupa u sezoni 1993/94. analizirali smo neke kinematičke karakteristike u fazi leta, te usporedili razlike između stare klasične i nove "V" tehnike skijaških skokova.

Usporedba dobivenih rezultata je pokazala da su skakači kod skakanja novom tehnikom više nagnuti prema naprijed, da za vrijeme leta zatvaraju manji kut sa skijama (gledano sagitalno), da su više savijeni u kukovima, te da postižu značajno duže skokove na manjoj visini skoka (promatrano negdje na sredini leta). Na dužinu skoka još uvijek najviše utječu, slično kao i kod klasične metode, visina leta i nagnutost skakača prema naprijed; međutim, ne smiju se zanemariti niti odgovarajući pregeb u kukovima, te odgovarajući položaj skija.

Ključne riječi: *skakači, kinematičke osobine leta, uspjeh*

Zusammenfassung

UNTERSCHIEDLICHE KINEMATISCHE PARAMETER DES FLUGES BEI DER KLASSISCHEN UND DER NEUEN 'V'-TECHNIK BEIM SKISPRINGEN

Auf dem Muster von 30 Spitzenskispringern, Finalisten des Weltcups auf Planica im Jahre 1990 und Teilnehmern am Weltcupbeginn in der Saison 1993/94, haben wir einige kinematische Parameter in der Flugphase analysiert und die Unterschiede zwischen der alten klassischen und der neuen "V"-Technik beim Skispringen verglichen.

Der Vergleich der Resultate hat gezeigt, daß die Springer, wenn sie die neue Technik verwenden, mehr nach vorne geneigt sind, daß sie sich während des Fluges mit den Skiern einen geringeren Winkel bilden (sagittal betrachtet), daß sie mehr in den Hüften gebeugt sind, und daß sie bedeutend längere Sprünge auf der niedrigeren Sprunghöhe erreichen (betrachtet ungefähr in der Mitte des Fluges). Die Länge des Sprunges hängt noch immer am meisten, ähnlich wie bei der klassischen Methode, von der Sprunghöhe und von der Neigung des Springers nach vorne ab; es dürfen aber weder die entsprechenden Hüftenbeuge, noch richtige Skistellung nicht vernachlässigt werden.

Schlüsselwörter: *Skispringer, kinematische Charakteristiken des Fluges, Erfolg*

Introduction

In 1992 a new flight technique, the so-called "V" technique, was established. In the primary phase of the study,

the researchers mainly determined its characteristics in experimental conditions, finding the following tendencies of the position in the flight phase (flight curve being 20 angular degrees):



The angle between skis in the "V" position should be from 33 to 39 degrees, with no hind-crossing of skis, as well as no twisting of skis greater than 20 degrees. The legs should be, in regard to the flight curve, at the point that is approximately 20 m from the take-off, at an angle from 45 to 49 degrees, the upper part of the body being from 33 to 36 degrees. To these experimental finds, we also wanted to add those that can be obtained completely from situationally-practical conditions. Thus we have decided to establish the basic kinetic characteristics of the flight in the new technique and to compare them with experimental finds as well as with the "old" classical flight technique in ski jumps.

The object and the 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 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 measurements was carried 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 carried 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:

1. Angle between the legs and the trunk: ALFA - α
2. Angle between the chord connecting the ankle joint and the shoulder joint: BETA - β
3. Angle between the skis and the chord connecting the ankle joint and the shoulder joint: FI - ϕ
4. Angle between the trunk and the arms: GAMA - γ
5. Flight height: FLH

6. Length of the jump: JUMPL

7. Style grade: STYLEG

Results

Table 1 shows the basic statistical parameters of the variables used:

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
FI2	22.1	4.58	36	15
FI3	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
STYLEG3	53.8	2.93	58	45

Comparison of the average values of individual jumps indicates a significant 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 more inclined towards the front) and in the position of the skis during the flight (FI): in the new technique they follow more the posture of the body. In the old technique the skis were usually positioned slightly below the horizontal plane (3 angular degrees), while in the new one they are positioned 3 angular degrees above the horizontal plane. On average, the ski jumpers were also slightly more bent 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.

The results of the regression analysis of performances of the jumps carried out on a criterion of the jump length are shown in Table 2:

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

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

	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

In short, if we sum up the results, we can conclude that from the jump-length point of view, the jumpers attaining greater flight height and thus achieving an optimal position of the angle between the body and the legs (ALFA) as well as between the body chord and the horizontal plane (BETA) are successful.

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 skis 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 ski jumpers, which has been established by regression analysis of the performance of ski jumpers in respect of the jump length (Table 2).

The variable FLH1 has shown length the greatest linear correlation with the jump (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 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 down 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 in 1990 and the start of the World Cup 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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