A COMPARISON BETWEEN THE KINEMATIC CHARACTERISTICS OF THE TRANSITION PHASE OF SKI JUMPING ON JUMPING HILLS WITH DIFFERENT CRITICAL POINTS

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Introduction

Ski jumping is an acyclic discipline with a relatively simple movement structure. Vaverka (1987) divided the ski jump into these phases: in-run, preparation for the take-off, take-off, transition, flight, preparation for the landing, landing and finish. All of these phases (except the finish) influence the final result of the ski jump, the length of jump. The new changes in the technique of this discipline have resulted in increased interest about the phase between the take-off and flight. This phase is callled the transition.

There are many external and internal conditions that influence the length of jump. The construction of the jumping hills, critical points, and the hill surface (snow, ceramic, plastic) are some of the major external factors. The purpose of this study was to investigate relationships between the kinematic parameters of the transition phase on jumping hills with different critical points and to determine the degree to which jumpers at various skill levels are able to adapt technique.

Problem

There have been few reported attempts to solve the biomechanical problems related to the transition phase (Arndt, 1995; Cambell, 1990; Chen, 1994; Denoth, 1987). In order to gain a better understanding of this part of the ski jump it is necessary to focus also on the main factors governing the take-off. The relatively short time in which the transition phase occurs means that only small corrections in the movements which were created during the take-off phases can be completed. In this study the multifactorial theory of the take-off (Vaverka, 1987), which contains: vigour, accuracy, rotation, aerodynamics, and arm activities was used in an attempt to solve the problem.

The different critical points as well as the surface of the in-runs can change some of the conditions for the ski-jumpers movements, particularly the in-run velocity. A higher in-run velocity will result in:

- a shorter time for the take-off,
- a higher magnitude of the aerodynamic forces,
- a higher forward moment of inertia,
- the ski-jumper having to complete the movement sequence for a quick and smooth transition from the take-off to the flight in a shorter amount of time.

In the present study we focused on two problems:

1. Are there any changes in the transition phase of the ski jump on jumping hills with different critical points?
2. Are there any differences in this phase between the groups of ski jumpers with various skill levels?

Methods

The study was conducted at events held at the following jumping hills:

- GP Frenštát pod Radhoštěm 1992 (K=90), n=59, surface ceramic
- Intersporttournee Innsbruck 1995 (K=109), n=45, surface snow
- World Championship in Ski Flight Planica 1994 (K=185), n=33, surface snow

The 2-D analyses were implemented using the System of Kinematic Analysis of Ski Jumping, which was presented at the XII. ISBS in Budapest (Vaverka, 1994). The transition phase was analyzed from the edge to 8-9m after the take-off. Using factor analysis we have chosen five angles out of 14 measured parameters. This parameters are expressed in graphical form in Fig.1.

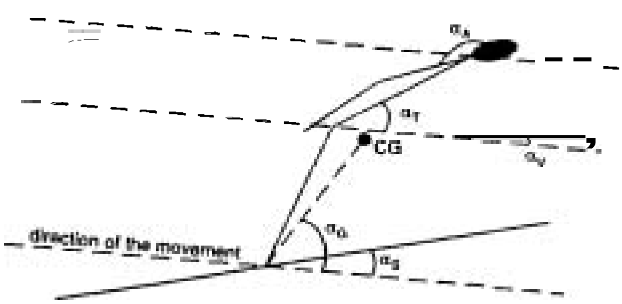


Figure 1: Selected parameters

Due to the different conditions experienced for recording of the movements we chose the distance 5.6m after the take-off edge. The analyses were provided for the set of competitors participating in the 1st jumping round (the set marked ALL, n=33-59). The sets of athletes were divided into three groups according to the length of jump (n=10-15, B - best, M - middle, L - low).

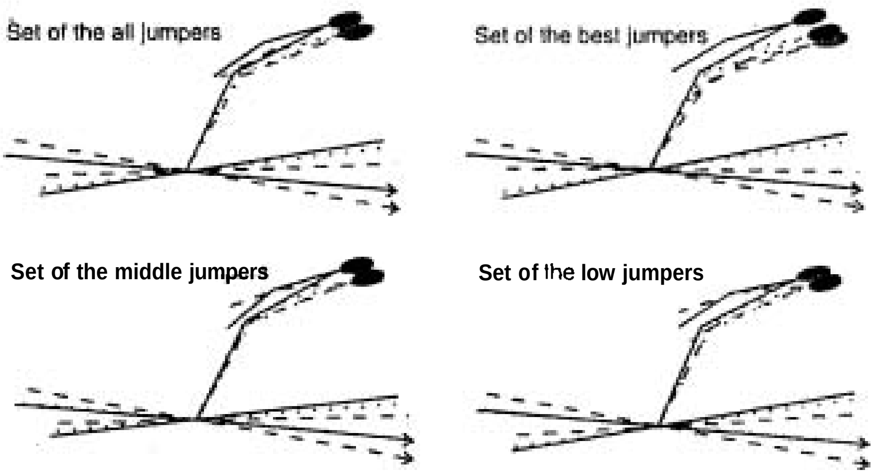
The statistical analysis package Statgraphics was used to compute basic statistical characteristics, multiple range of analysis, one-way analysis of variance, correlations, and factor analysis.

Results and discussion

The basic statistical characteristics are given in Table 1. The angles α_G, α_T, α_A, α_S are included in the analysis of the path of the centre of gravity (ski jumper+ski). Its shape is characterized by the angle α_V, which increased in the ski flight event. The angles α_T (aerodynamic quality of the jumper's position in the transition phase) and a, (rotation of the system ski jumper+ski) were decreased for the jumping hill K=109m. The movement of the ski was the highest in the event which took place on the ceramic in-run surface (K=90m). In Fig.2 the graphical comparisons between the groups of jumpers with different lengths of jump are presented.

Table 1
Measured parameters of the transition phase
GP Frenštát 1992, Intersporttournee Innsbruck 1995, WCh Planica 1994

Variable	*GP 92 n=59*		*IN 95 n=45*		*PL 94 n=33*		*Differences * p < 0.05*		
	MEAN	*S.D.*	*MEAN*	*S.D.*	*MEAN*	*S.D.*	*GP-IN*	*IN-PL*	*GP-PL*
LJ	77.78	6.42	93.76	8.73	123.35	29.92	*	*	*
AV	83.94	0.50	88.52	0.76	102.11	0.76	*	*	*
α_G	57.88	3.42	54.53	2.95	57.91	4.45	*	*	
α_T	32.98	4.20	27.43	3.57	32.38	4.14	*	*	
α_S	14.61	5.35	12.30	5.20	12.31	7.44	*		*
α_A	200.13	8.91	200.50	8.85	198.89	10.35			
α_V	5.14	0.47	5.30	0.51	10.71	0.61		*	*



LEGEND: —— GP FRENŠTÁT 1992. K=90m
. . . INTERSPORTTOURNEE INNSBRUCK 1995, K=109m
- - WCh PLANICA 1994, K=185m

Figure 2: Comparison between the roups of jumpers.
The jumping hills with different critical points.

The K=90m jumping hill: The trunk was more open, the centre of gravity was shifted to the back. This was probably related to the high vigour of the take-off on the jumping hill with the ceramic in-run. It is important also to consider the skill level of the athletes in this event as beginners will have a lower level of rotation.

The K=109m jumping; hill: The arm location was close to its position in the flight. The rotation and the movement of the ski were stopped.

The K=185m jumping hill: The ski position shows, that the transition into the flight position was at the beginning. The high velocity of the ski-jumpers increased the distance to the end of the transition phase. The continuous transition into the flight phase existed only for the groups of jumpers with high skill level (α_{GB}=54.05, α_{GL}=61.30). The difference in the angles expressing the aerodynamic quality (α_{TB}=29.77, α_{TL}=35.39) was evident in the take-off (Jošt, 1994). The ski jumpers with the low skill level practised the jump with a safe transition phase into flight. The best jumpers make the movement during the transition phase continuous (Fig.3).

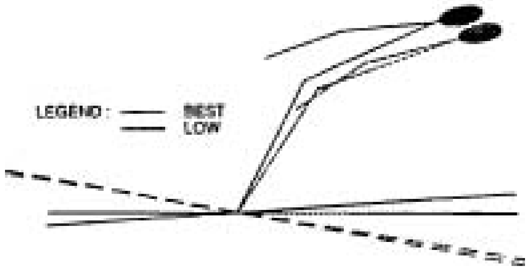


Figure 3: Comparison between the groups of Jumpers with different skill level (WCh Planica 1994, K=185m)

Conclusions

1. There exist statistically significant differences between basic angles and velocity characteristics for the transition phase on jumping hills with different critical points.
2. The best jumpers differ from the middle and low level athletes in the velocity of rotation and continuity of the movement in the transition phase.
3. The most progressive rotation in the flight position were found on the K=109m jumping hill.
4. We suspect that psychological factors may have influenced the sequence of movements of the athlete with low skill level performing on the K=185m jumping hill.

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