A KINEMATIC FOCUS ON THE RELATIONSHIP BETWEEN THE MAIN PHASES OF SKI JUMPING AND PERFORMANCE AT THE INNSBRUCK 1995 EVENT

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Introduction

Ski jumping is a sport discipline which consists of a wide range of movements. The jump is typically divided into a series of phases: in-run, take-off, transition, flight and follow up phase, the landing. Although there are a number of studies concerning the kinematic of ski jumping (Hochmuth, 1959; Gisler et al., 1977; Komi et al., 1974; Baumann, 1979; Meier, 1977; Schwameder, 1993; Arndt eta l., 1995 and others). It is difficult to obtain information which focuses on the entire sequence of the ski jumper's movements.

The methods used for the lunematic analysis of ski-jumping have incorporated 2D, 3D analysis, and pan and tilt cameras (Yeadon, 1989; Schwameder 1993; Drenk 1988). The relationship between the take-off and the flight phases has been studied extensively using several cameras. More recently researchers have focused on the transition phase (Arndt et al., 1995). The fluent transition from the take-off to the flight position is the premise of Straumann's (1926, 1965) ski jumping theory. Denoth et al. (1987) emphasized the consequences of subsequent phases.

Objectives

The objectives of the Innsbruck 1995 project were to:

- describe the kinematics of all of the main jumping phases,
- search for the relevant lunematic variables which will provide information about the quality of the ski jumper's movements in the observed phases (and to subsequently elaborate the resulting models for training),
- describe the relationship between the main phases and the final performance (the length of jump).

In this presentation we will focus on **the relationship between each of the main phases of the ski jump and the length of jump.**

Methods

The research was conducted during the first and second competitive rounds of the K120 World Cup event Intersporttournee Innsbruck on January 4, 1995. The jumps were taped using seven cameras (Fig. 1). Three research groups - one from Czech Republic, Slovenia, and Canada participated in the project.

The five main phases: in run, take-off, transition, flight 1, and flight 2 of the ski jump were recorded.

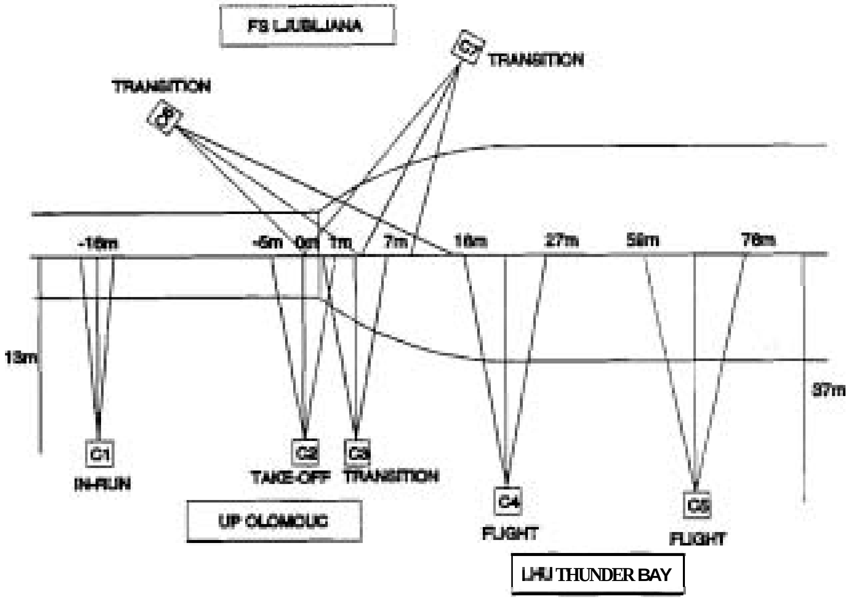

Figure 1: Cameras location in jumping hill Innsbruck 1995, K120

The kinematic data were processed using the 2D Kinematic Analysis of Ski Jumping System developed by the Czech group (Vaverka et al., 1994), the Peak Performance 2D Analysis System (CAN), and the 2D and 3D Consport Motion Analysis System (SLO). The following groups of variables were evaluated: angles describing the position of body segments and ski; angles of attack (position of body segments and ski with respect to the direction of the in-run and flight); the velocity of the center of mass in the horizontal, vertical and final directions; the slope of the flight curve and the relative distance of it fiom selected points along the profile of the hill. Total number of evaluated parameters in different phases: in-run 10, take-off 11, transition 14, flight 11.

Although the tapes were digitized throughout each of the phases, the key variables were processed at 12 selected positions of the jump at specific distances fiom the edge (fiom 18m before to 75m after the edge, see Fig 2).

The statistical methods used included descriptive characteristics, analysis of variance, regression, correlation, and factor analysis. All statistical procedures have been processed using the package STATGRAPHICS.

Results

In this paper we have focused on only one part of the entire project, the relationship between each of the different phases of the jump and the final criterion (the length of jump). These relationships were studied using factor analysis. The intercorrelation matrix of each observed phases served as the input data for the analysis. The factor analysis enabled us to get a general view of the structure of intercorrelation relationship among the observed variables for each analyzed position.

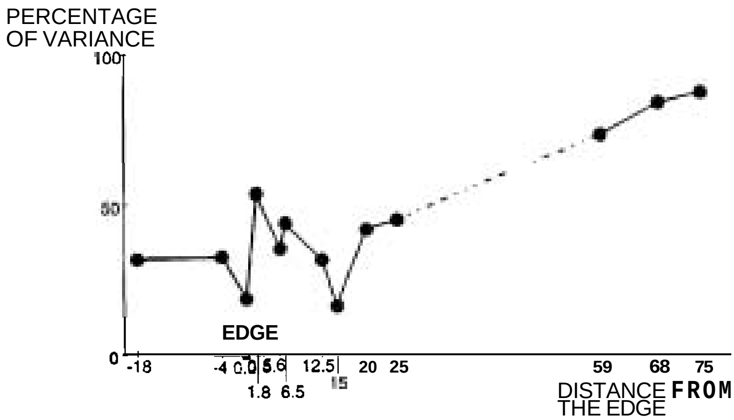

Fig. 2: Percentage of explained variance in different ski-jumping phases
Innsbruck 1995, K120

The final results of the factor analysis are presented in Figure 2. The percentage of explained length of jump variance varies from 17% to 87%. The percentage of explained variance oscillates from 30% to 40% in the range 18m prior to the edge of the take-off platform up until 20-25m after take-off. There are three deviations in that section (take-off edge Om, 19%, 1.8m after the edge 53% and 15m from the edge 17%). The explained jump length variance has increased over the course of the flight phases (60m-74m from 83% -87%).

Discussion

The percentage of explained variance of the jump length in the take-off and transition phases is comparable with findings in the professional literature where the relationship between variables and criterion has been expressed by R^2=.2-.35 (Baumann, 1979; Schwameder, 1993 and others). Arndt et. al (1995) has found the value R^2 =.2 for the velocity parameters at the edge. According to Denoth et al. (1987), the contribution of isolated slu-jumping phases to the length of jump is very low. This author recommended studying slu jumping by examining all of the phases.

The results for the analysis of the position at the edge and early flight phases have yielded some quite different results where 19%, and then 17% of the explained variance seems to be very low especially in comparison to the high level of variance (53%) at the 1.8m distance from the edge. This finding poses a number of questions and hypotheses. Is the information at 1.8m from edge of a higher quality then that computed at the edge or is the quality of the evaluated variables at the distance 1.8m more informative then this one at Om? The results 17% in the 15m distance found in our study differ from finding of Arndt et al. (1995) who has found 84% explained variance of the jumping length at 17m from the edge. Further analysis will focus on these and other questions.

Conclusions

The factor analysis has confirmed that the quantum of explained jumping length variance in the in-run, take-off, transition, and early flight (-1.8m to 25m) vary from 30% to 40%. The percentage of explained variance of the jumping length in 60m-75m flight increased up to 85%. The partial results of the research indicated the necessity to search for new theoretical outputs for the evaluation of biomechanical variables in the take-off and transition phases. It seems that simple analysis of correlation dependence provides little information. The application of factor analysis on the kinematic data provides for a clearer picture of the interrelationships among variables.

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