THE ACCURACY OF THE SKI-JUMPER'S TAKE-OFF

Vaverka,F.[1], Janura,M.[1], Kršková,M.[2], Elfmark,M.[2], Salinger,J.[1]

1) Laboratory of Human Movement Studies, Palacký University Olomouc
2) Computing Center, Palacky University Olomouc

INTRODUCTION

The accuracy can be defined as the ability of the jumper to finish the take-off at the correct time. The take-off is accurate in the moment when the acceleration of the centre of gravity is finished and passes through the edge of the take-off area. According to Hochmuth (1958) the take-off is finished at the moment when the value of the take-off force meets the level of gravitational force affecting the mass of the jumper and his equipment. Baumann (1979) expressed completion of the take-off as the moment in which the velocity of the body's centre of gravity is reached perpendicular to the take-off area. Both definitions show two principle ways for exact diagnosis of the factor accuracy. In training practice three terms are used describing the quality of the accuracy: accurate, early, late.

The present study focuses on the following problems:

- quantification of the accuracy,
- relations of accuracy to the other factors of the take-off and to the length of the jump,
- creation of the model which represents the moment of completing the take-off.

METHOD

The following methods were used:

- Dynamometry of the take-off in the natural conditions of the jump. The dynamometric platform, 6 m long and built in the jumping hill K 92 m in Frenštát p.R., enables measurement of two key factors of the take-off (Vaverka, 1987):
  . The vertical speed of the jumper's center of gravity taken in the final 6 m of the take-off. We call it VIGOUR (VI) expressed in [m.s-1].
  . The distance from the edge of the take-off in which the take-off is completed is called ACCURACY (AC) expressed in [m].

  This method has been used and developed systematically since 1978 and more than 800 jumpers were examined.
- The kinematic analyses was elaborated specially for ski-jumping.

  The method enables modeling of the jumper's position according to the chosen distance from the take-off edge, the time of the movement, and desired angle parameters of the body's position. (Vaverka et al., 1992). About 450 take-offs from different events have been analysed since 1990.

RESULTS

Quantification of the take-off accuracv and relation to the length of jump

Table 1 shows the general statistical characteristics of the measured values of accuracy using dynamometry. We can see that the data measured on plastic in the period 1978-1989 are

Table 1

The average values of the accuracy (AC)
of the take-off measured dynamometrically in different time periods
and correlation between the accuracy and the length of jump (LJ)

time period	1977 - 1983	1987 - 1989	1990
surface	plastic	plastic	ceramic
n	408	406	107
MEAN S.D.	0.26 0.22	0.24 0.18	0.14 0.12
$r_{LJ,AC}$	-0.380^{+}	-0.259^{+}	0.0543

+ $p < 0.01$

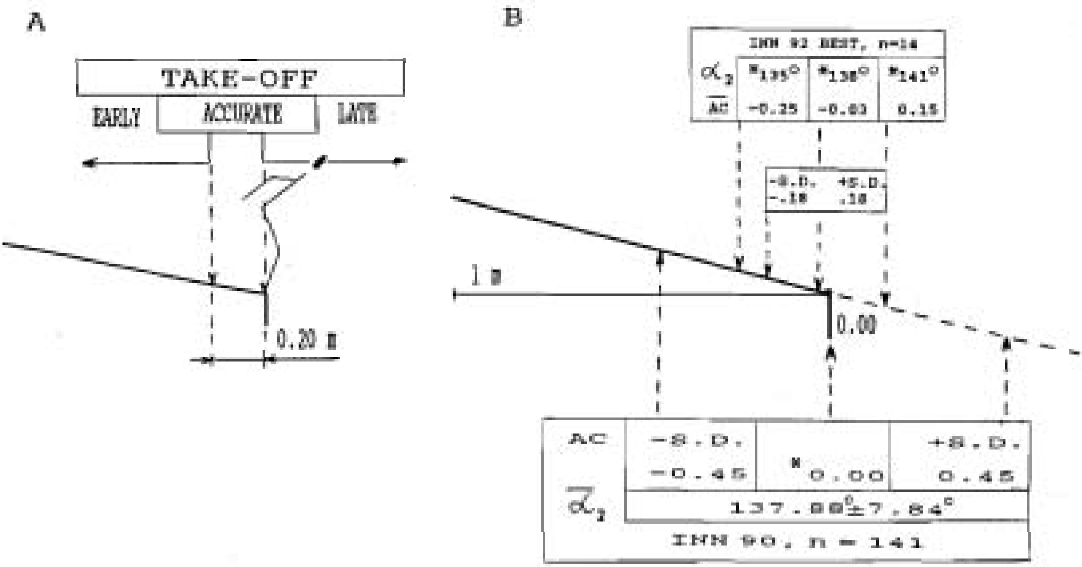

Fig.1 A,B The accuracy of the take-off based on dynamometric measurement (A) and kinematic analyses (B)
Notice: Values marked * are independent variables which were input data to the individual's cinematic model and non marked values are computed.

almost the same, but the accuracy measured on ceramic is different. The last measurements on the ceramic showed more frequently the value AC = 0.00 than before. We can see that the distribution of the accuracy is different from normal Gausse curve and the concentration of the values AC = 0.00 is very high.

Relations of the accuracy to the length of the jump as computed by the Pearson correlation coefficient, is problematic (Table 1). The values of correlation coefficients are negative, two out of three are statistically significant and very low. The reason for these low relations is abnormal distribution of the accuracy.

In our previous study (Vaverka et al., 1991) we investigated the relation between the two factors of the take-off measured dynamometrically (vigour, accuracy) and the length of the jump. Statistical analyses showed that the statistic model expressed by three-dimensional exponential relationship between the length of jump, and take-off vigour and accuracy fits very well with reality.

Discovering of the take-off accuracv model

Fig. 1A schematically expresses all three variants of the take-off accuracy measured dynamometrically. The optimum range is 0.00-0.20 m before the edge, which is classified as an accurale take-off.

For trainers, a very interesting problem is how the visual model looks (position of the jumper) at the moment of take-off completion. A very simple, but informative, model is taken from the angles describing the body's position. Previous research found that the key angle characterising the take-off is the knee angle a 2 (Baumann, 1979, Vaverka, 1987).

This angle is the centre of our concentration. From 107 dynamometrically measured and kinematically analysed take-offs in Frenštát p.R. 90 (all evidently late take-offs were discarded) the angle values of the jumper's position were computed in the moment of the take-off completion and at the adge. The set of 140 jumpers from the competition Innsbruck 92 were analysed by using of kinematic analyses (Vaverka et al., 1992). The results of statistical elaboration of measured data are given in graphical form in Fig. 1B.

CONCLUSIONS

1. The dynamometric and kinematic analyses enables finding the range around the edge in which the take-off is accurate. It is the distance 0.20 m before and 0.15 m after the edge.
2. The optimum value of the knee angle in the moment of take-off completion was found to be a 2 = 138^o. The take-off is completed with a very high probability in the range of knee angles a 2 = 135^o - 141^o. Identification of the knee angle a 2 = 138^o in longer distances than 0.20 m before the edge is diagnosed as an early take-off and longer than 0.15 m after the edge is late.
3. The diagnostic systems, the dynamometry in Frenštát p.R. and cinematic analyses of the ski-jumping, elaborated in our Laboratory, enables quantification of the take-off accuracy very sensitively and are very useful in the training of ski-jumping.

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