On the association of inrun velocity and jumping width in ski jumping

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Abstract

In ski jumping it is beyond any doubt that a larger inrun velocity results in a larger jumping width. While there have been correlations reported, we are not aware of information on the actual size of this association.

From the homepage of the International Ski Federation we gathered the results of all men's ski jumping World Cup competitions in the 2007/08 winter season. The final data set comprises 1652 jumps performed by 119 different jumpers in 22 competitions from 14 jumping hills. After proper adjustment for individual jumper, competition, and jumping hill by linear mixed models we find an expected gain of 4.13 m [3.38, 4.87] jumping width for each additional km/h of inrun velocity.

Introduction

In ski jumping it is beyond any doubt that a larger inrun velocity results in a larger jumping width(Virmavirta et al., 2009; Muller, 2009). While there have been correlations reported (0.63 and 0.43 in 50 and 30 jumps from a single competition)(Virmavirta et al., 2009), we are not aware of information on the actual size of this association. German TV commentators obviously believe that an additional km/h of inrun velocity yields a gain of up to 10 metres of jumping width. With the research reported here, we aim for a more realistic estimate of this association in a large sample.

Data

From the official homepage of the International Ski Federation (FIS, www.fis-ski.com, accessed at 2nd of April, 2008) we gathered the results from all men's ski jumping World Cup competitions in the 2007/08 winter season. We restricted ourselves to the results of large hill individual competitions. We especially excluded team, normal hill and ski flying competitions.

From each competition we collected information on all jumps from the 1st and final round. We recorded the specific athlete, his inrun velocity (in km/h) and jumping distance (in m). Details on how these quantities are measured are available in the FIS' international competition rules (http://www.fis-ski.com/data/document/icr_jp_2008.pdf, accessed 10th of January, 2010). We note that wind speed, obviously also an important predictor for jumping width, is not given in the official results.

Statistical Methods

The association between inrun velocity and jumping width was assessed by a regression model with jumping width as the response and inrun velocity as the single covariate. To adjust for the fact that jumping widths are correlated (1) within the individual jumper, (2) within the same competition, and (3) within the individual jumping hill, we included three random effects for jumper, competition and jumping hill in the model, where the random effect for competition was nested within that for jumping hill. The resulting linear mixed model with three random effects was fitted with SAS (Cary, NC, USA), PROCs HPMIXED and GLIMMIX, Version 9.2. All estimates are given with their 95% confidence intervals. As a sensitivity analysis, we also fitted the final model allowing additionally, (1) for an interaction between jumper and jumping hill, and, (2) for heterogeneity of inrun velocity with jumper, competition and jumping hill by adding another four random effects for those interactions.

Results

Our final data set comprises the results of 1672 jumps performed by 119 different jumpers in 22 competitions from 14 jumping hills. For twenty jumps, inrun velocity was missing in the official results, these jumps were deleted from the analysis.

A scatter plot for the whole data set is given in figure 1. As can be seen from the figure, the assumption of a linear relationship between inrun velocity and jumping width is very plausible. The unadjusted correlation between inrun velocity and jumping width was found to be 0.30 [0.26, 0.34] and the regression coefficient for inrun velocity as 1.33 [1.12; 1.53].

After proper adjustment for individual jumper, competition, and jumping hill this regression coefficient was 4.13 [3.38, 4.87]. The variance components for the random effects are given in table 1. Note that the three random effects explain 76.2 % (sum of the three RE variances / total variance) of the model variance. By far the largest part of the variance is explained by the effect of the jumping hill.

Using the model with seven random effects as a sensitivity analysis yields a virtually identical regression coefficient of 4.13 [3.38, 4.88] and an explained variance of 88.0 %.

Discussion

Our analysis of 1672 jumps performed by 119 different jumpers in 22 competitions from 14 jumping hills in 2007/08 finds an expected gain of 4.13 m [3.38, 4.87] jumping width for each additional km/h of inrun velocity after adjusting properly for jumper, jumping hill, and competition. While this gain is highly statistically significant, its actual relevance is maybe smaller than expected: The mean range of inrun velocities across the 22 competitions is 2.2 km/h, meaning that the jumper with the largest inrun velocity has an expected gain of (4.13 x 2.2) = 9.1 metres of jumping width as compared to the jumper with the smallest inrun velocity. However, the mean range of actual jumping widths is 37.2 metres, indicating that there are other factors, besides inrun velocity, contributing largely to the final jumping width.

Reference List

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Virmavirta, M., Isolehto, J., Komi, P., Schwameder, H., Pigozzi, F., Massazza, G., (2009). Take-off analysis of the Olympic ski jumping competition (HS-106 m). Journal of Biomechanics 42**,** 1095-1101.

Table 1: Estimated variance components for the three random effects jumper, jumping hill and competition (jumping hill) and the residual error.

Effect	**Value**	**[95% CI]**
Jumper	29.2	[21.8, 41.1]
Jumping hill	73.7	[35.6, 233.4]
Competition (jumping hill)	7.7	[3.2, 36.4]
Residual	34.6	[32.3, 37.2]

Figure 1: Scatter plot of jumping width versus inrun velocity for the whole data set (N=1652). The equation for the given regression line is jumping width(m) = -1.73 + 1.33 * inrun velocity(km/h).