Bulletin of the *Transilvania* University of Braşov
Series IX: Sciences of Human Kinetics • Vol. 13(62) No. 2 – 2020
https://doi.org/10.31926/but.shk.2020.13.62.2.18

IMPROVING PERFORMANCE BY ADOPTING THE OPTIMAL FLIGHT POSITION IN SKI JUMPING

Wilhelm Robert GROSZ[1]

Abstract: *The present research aimed at the specific actions of the third phase of ski jumping after the takeoff, respectively the flight distance covered by the subjects until they reached the V-style posture, as well as the ski-opening angle. The subjects of the study were four athletes, members of the national junior ski jumping team. The research was carried out on the HS 100 m hill in Râșnov. The initial testing consisted of three complete jumps. Subsequently, for a period of 30 days, specific training methods consisting of imitative exercises were implemented, focusing on the third phase of the ski jump. In the final testing, the themes were the wide spread of the lower limbs above R2, as well as the maintenance of the skis spread in the plane that includes the body in order to benefit from the maximum lift. The results of the research highlighted the close connection between ballistics and aerodynamics, the achievement of the flight speed, as well as the increase of the lifting surface due to the identification of the optimum angle of ski spread. An increase in length performance was observed for all four subjects.*

Key words: ski jumping, third phase – the flight, imitative exercises, ski-opening angle.

1. Introduction

This research aims to identify the optimal flight position and, implicitly, to obtain better performance in increasing jump length in the third phase in ski jumping. Due to the acyclic nature of the type of movement in ski jumping [1] and to the degree of complexity of each phase (inrun, take-off, flight, landing), this study could be performed only after having learned) the specific stereotype actions of first, second and third phases for each subject/athlete participating in this research.

The premises for correct executions in phase II (take-off) were created with a good timing and optimal rapid force indices by adopting an aerodynamic position on the inrun track, distributing correctly the jumper's centre of mass (CoM) and counteracting external forces in R1 (inrun).

[1] Department of Physical Education and Special Motricity, *Transilvania* University of Braşov

In the second phase of the jump (take-off), it was found that the ratio between ballistics and aerodynamics of the research subjects was efficient, but the jump lengths did not increase, this being the reason why we insisted on the third phase actions of the ski jump in order to improve length performance.

The key factors identified by Seo et al. [5] for achieving longer flights would be a sharp ski-opening angle in the first part of the flight, in order to reduce the drag on the jumper-ski system and maintain a constant angle during the second part of the flight.

The ground effect on the jumper during V-style flight has a major contribution on the lift and the reduction of drag before landing [6].

The results of the research conducted by Sasaki and Tsunoda indicated that the aerodynamic force that an athlete acquired in the flight phase was different for each jumper [4]. They also specified that the aerodynamic force required in the flight phase was different from one jumper to another. According to them, the lift and drag forces differ, as they are not constant.

Virmavirta states that it is practically impossible for a jumper to precisely control the ski V angle in the first phase of the flight. The opening of the V angle has been identified as optimal when it has a constant value between 25°-30° and the ski angle of attack is between 25°-40° [7].

Obtaining a flat V-shaped ski during the flight can be achieved by an inversion at the ankle joints, Cutter considering that an ankle angle of 20° is maximally feasible [7]. This action allows the adoption of both the V-style and the H-style by creating a very wide distance between the parallel skis, with a very small V angle [8].

The authors J. Petrat and V. Bessone stated that a number of factors influence the performance of ski jumping, factors that must be determined and classified to achieve objective statistics [3].

Studies on the jumpers' flight position in the wind tunnel, using the latest equipment, highlighted the need to include the first phase of flight in the actual execution, which will lead to improved flight position with the aim of reaching an individualised style [2].

2. Research Purpose

The aim was to identify the optimal flight position in order to increase the jump length.

3. Objectives

The proposed objectives were to:

- optimise the actions in the third phase of ski jumping;
- easily adapt technical flight in V-style and H-style;
- keep the V-style and H-style skis horizontally open.

4. Hypothesis

If we assume the subjects have optimised the technique of the third phase in ski jumping through specific means and methods and have created a stereotype in adopting the H-style, the jump length may be significantly improved.

5. Material and Methods

5.1. Subjects

The research was carried out on 4 male subjects - members of the national ski jumping B team, aged between 13 and 14 years, named subject 1, subject 2, subject 3 and subject 4.

Body indices of the subjects Table 1

Crt. No.	Subjects	Date: June			Date: July		
		Weight [kg]	Height [cm]	BMI	Weight [kg]	Height [cm]	BMI
1.	Subject 1	34.40	149	15,3	34.90	150	15,1
2.	Subject 2	40.90	148	18,3	41.20	149	18,5
3.	Subject 3	40.50	149	18	40.80	149	18
4.	Subject 4	38.70	146	17,8	39.10	146	18,3

5.2. The content of the research

The research was carried out on the Râșnov HS 100m hill, in Brașov county, on synthetic grass.

The initial testing (TI) consisted of 6 jumps on HS 100m hill, adopting the V-style flight. After that, during 20 daily trainings aiming physical training, ski jumping imitation exercises were performed focusing on the consolidation and improvement of the H-style flight, with a small V-style degree. These specific systems were imitation flight exercises using TRX harnesses, static imitation jumps using a take-off frame or imitation jumps from a rolling platform or a Bosu ball.

The final testing (TF) consisted of 6 jumps on HS 100m hill, on synthetic grass, positioning the skis in H-style, with a very low V angle.

The jump lengths at both TI and TF were recorded and transformed into points according to the K hill point. The opening angle of the ski tips was measured, at a distance of 25m from the hill edge, with the help of a Sony video camera, a Benq video projector, a projection panel and Skill protractor.

The testing conditions were identical, with no wind, identical waxing for all subjects' skis and an air temperature of 20°.

6. Results and Discussions

Table 2

HS100 Results adopting the V-style of flight at TI

Subject	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	**Total points**
Subject 1	80	**40**	82	**44**	81	**42**	83	**46**	83	**46**	84	**48**	**266**
Grades	46,2°		49,4°		47,1°		50,2°		49,1°		48,1°		
Subject 2	79	**38**	79	**38**	80	**40**	82	**44**	83	**46**	82	**44**	**250**
Grades	51,1°		50,4°		50,8°		52,2°		50,1°		52,2°		
Subject 3	84	**48**	83	**46**	82	**44**	83	**46**	82	**44**	81	**42**	**270**
Grades	46,2°		48,1°		48,3°		49,2°		50,1°		49,7°		
Subject 4	80	**40**	81	**42**	83	**46**	84	**48**	84	**48**	82	**44**	**268**
Grades	49,9°		50,1°		48,7°		49,1°		48,8°		50,2°		

Table 3

HS100 Results adopting the H-style of flight with low V at TF

Subject	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	[m]	[p]	**Total points**
Subject 1	85	**50**	88	**56**	87	**54**	86	**52**	88	**56**	89	**58**	**326**
Grades	28,1°		26,2°		26,8°		28,6°		27,1°		25,8°		
Subject 2	84	**48**	87	**54**	88	**56**	89	**58**	87	**54**	90	**60**	**330**
Grades	29,4°		27,4°		27,1°		26,9°		27,1°		26,8°		
Subject 3	86	**52**	87	**54**	88	**56**	90	**60**	91	**62**	92	**64**	**348**
Grades	33,1°		31,4°		29,7°		29,1°		28,7°		29,1°		
Subject 4	90	**60**	88	**56**	90	**60**	92	**64**	90	**60**	92	**64**	**364**
Grades	29,7°		30,8°		30,1°		29,5°		29,9°		28,8°		

7. Research Data Interpretation

Table 4

The average values of the opening angle for the subjects at TI and TF

Subject	The average values for V angle at TI	The average values for H angle with low V at TF
Subject 1	**48,35°**	**27,10°**
Subject 2	**51,13°**	**27,45°**
Subject 3	**48,6°**	**30,18°**
Subject 4	**49,46°**	**29,80°**

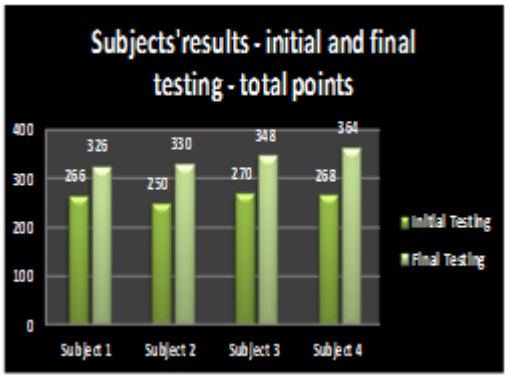

Chart 1. *Comparison of initial results vs.*

final results total points for the four subjects

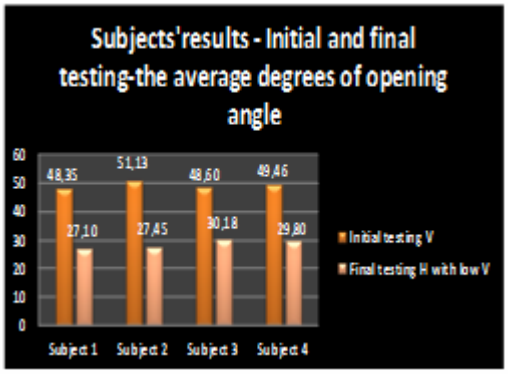

Chart 2. *Comparison of initial results vs. final results –average degrees of the ski opening angle*

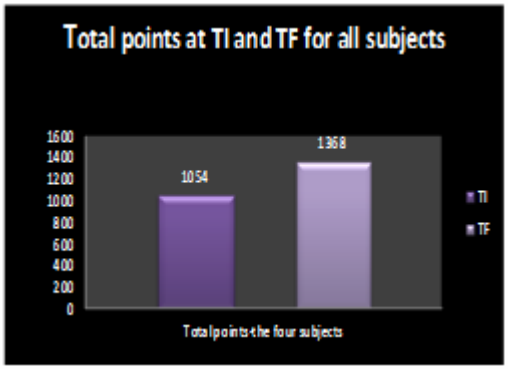

Chart 3. *Comparison of initial results vs. final results for all subjects*

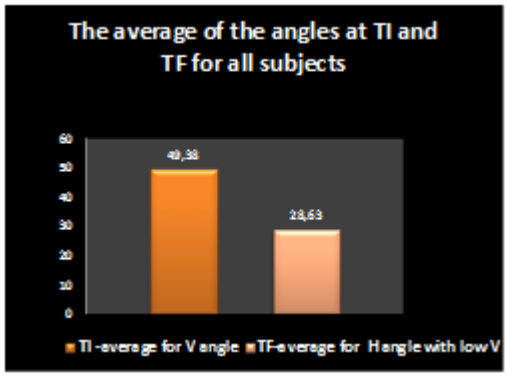

Chart 4. *Comparison of initial results vs. final results -average angles for all subjects*

Subject 1 – obtains 266 points at TI, at an average of the ski opening angles in V-style of 48.35°; at FT, 326 points are obtained in H-style with a small V, having an average of the ski opening angles of 27.10°. An increase of 60 points was recorded.

Subject 2 – achieves 250 points at TI, at an average of the ski opening angles in V-style of 51.13°; at TF, 330 points in H-style with a small V, having an average of the ski opening angles of 27.45°. The total score increased by 80 points.

Subject 3 – obtains 270 points at TI, at an average of the ski opening angles in V of 48.60°; at TF, 348 points in H-style with a small V, having an average of the ski opening angles of 30.18° and the total points increased by 78 points.

Subject 4 - achieves 268 points at TI, at an average of the ski opening angles in V-style of 49.46°; at TF, 364 points in H-style with a small V, having an average of the ski opening angles of 29.80°. An increase of 96 points was recorded.

8. Conclusions

1. The results of the research highlight that a lower of ski opening angle in H-style flight causes a better lift and, subsequently, longer jumps on HS100m for all involved subjects.
2. The research results show a high level of objectivity due to the very small differences in weight index (BMI) of the four subjects.
3. Performing the specific stereotype actions automatisation of the technical component in the third phase in ski jumping with the aim of reaching the optimal flight position at the end of the take-off has a special importance in order to obtain good length performances on HS100m hill.
4. The individualised approach of the technical preparation for the third phase of ski jumping in relation to the anthropometric peculiarities of the subjects, as well as the degree of mobility at the ankle joints are essential to improving the flight technique.

References

1. Balint, L., Grosz, W.R. et al.: *ABC-ul în schi sărituri Teoria şi Metodica Instruirii de Bază (ABC in ski jumping Theory and Methodology of Training Base*). Braşov. Editura Universităţii Transilvania, 2009.
2. Jung, A., Staat, M., Müller, W.: *Optimization of the flight style in ski jumping*. In Proceedings of the 11th World Congress on Computational Mechanics (WCCM XI), 5th European Conference on Computational Mechanics (ECCM V), 6th European Conference on Computational Fluid Dynamics (ECFD VI), Barcelona, Spain, 20–25 July 2014, Retrieve from: https://pdfs.semanticscholar.org/bb1f/68332effce99d4ab57a8fe9dc1011b955bbd.pdf?_ga=2.64725356.25672851.1596386729-39228007.1568107136
3. Petrat, J., Bessone, V.: *Improving performance in juvenile ski jumping: Optimization of ski angles in the flight phase*. Paper presented at the ISBS Proceedings Archive, 35th Conference of the International Society of Biomechanics in Sports, Cologne, Germany, June 14-18, 2017. Retrieved from: https://www.semanticscholar.org/paper/IMPROVING-PERFORMANCE-IN-JUVENILE-SKI-JUMPING%3A-OF-Petrat-Bessone/62fccfde6aa75880e5903a66c16206bb07785030#citing-papers
4. Sasaki, T., Tsunoda, K.: *Aerodynamic force during flight phase in ski jumping.* In: Muller E., Schwameder H, Raschner C, Lindiger S, Kornexl E, editors. Science and Skiing II, (2001) Hamburg: Dr. Kovac Verlag, p. 115-128.
5. Seo, K., Murakami, M., Yoshida, K.: *Optimal flight technique for V-style ski jumping*, Sports Engineering, vol. 7, 2004, pp. 97-103. Retrieved from https://link.springer.com/article/10.1007%2FBF02915921
6. Seo, K., Watanebe, I., Murakami, M.: *Aerodynamic force data for a V-style ski jumping flight*. In: Sports Engineering, vol. 7, 2004, pp. 31-39. Retrieve from https://link.springer.com/article/10.1007/BF02843971
7. Virmavirta, M., Kivekäs**,** J.: *Aerodynamics of an isolated ski jumping ski*. In: Sports Engineering 22 (1), 8, 2019. Retrieved from https://link.springer.com/article/10.1007/s12283-019-0298-1
8. https://en.wikipedia.org/wiki/Ski_jumping_techniques Accessed: 12-03-2020.