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Effect of kinaesthetic differentiation of the in-run position on the jump length in Polish national ski jumpers

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D Data Interpretation
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abstract

Background: The aim of study was to evaluate the effect of kinaesthetic differentiation during the in-run position on the in-run speed and jump length in ski-jumping team.

Material and methods: The examinations were conducted on a group of 14 elite athletes from the A (n=7) and B (n=7) national ski-jumping team. The measurement of the angle of attack for an athlete maintaining the in-run position was made using the Zebris CMS 10 device for a precise and replicable analysis of spinal mobility.

Results: Mean length of the jump in team A was 97.16 (50.95%) ±2.78 for the first jump and 93.58 (49.05%) ±4.23 for the second one. In team B, the jump length was 87.75 (51.27%) for the first jump and 83.41 (48.73%) ±5.77 for the second one. The difference between the jump length of the 1st and the 2nd jumps was statistically significant at $p < 0.05$.

Conclusions: In athletes from team B, lower angular deviations were observed in the in-run position, which means that these athletes were characterized by better reproduced position, whereas they adopted a relatively higher in-run position compared to athletes from team A.

Key words: ski jumping, kinaesthetic differentiation, jump.

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INTRODUCTION

Final score in ski jumping depends on a number of factors which concern correct in-run position, in-run length, take-off and the flight phase. Apart from the technical components, sports performance in ski jumping is significantly affected by the muscle power in the lower limbs, body mass and several motor abilities [1,2,3]. The optimal in-run position is characterized by using a maximally aerodynamic body position of an athlete, which directly translates into the in-run speed. The in-run speed of an athlete has an direct effect on the length of the ski jump [4,5,6,7,8,9]. A mistake in the first phase of the ski jump, such as an incorrect in-run position, may lead to consequences which cannot be reversed during other phases [1]. The take-off phase in ski jumping is performed automatically. The efficiency of performing the automated activity by the human body depends on the receptors located in muscle spindles and tendons. Proprioceptors transfer signals from the joints and ligaments and provide information about the angular position of the joint, whereas inner ear receptors inform about angular movements of the head [10, 11]. In ski jumping, proprioception is responsible for the analysis of the variables received from athlete's body during the in-run at the speeds exceeding 90 km/h. The time for the athlete to make a decision on the instant of the take-off is merely 0.25 to 0.30 s [6, 7].

Under static conditions, typical of the ski jumper's in-run position, the information is transferred to the central nervous system in a continuous manner. The flow of information from the receptor to the effector ranges from 70 to 120 ms. Control, which is the key factor in the effective in-run position, consists of maintaining or continuously correcting the motor task as a response to varying stimuli, external conditions, which, in the case of overdriving, allow for changes in the opposite direction [10].

Under dynamic conditions at the take-off, when the athlete needs to change the position, the movement control occurs automatically and the automated movement is composed of individual stages, with the final result being information about performing the task. In ski jumping, a mistake at the moment of take-off related to the control of the movement sequence has an effect on the final score and, consequently, poorer overall performance [10]. Striving for high scores in ski jumping is first and foremost connected with facilitation of the automatism connected with sensorimotor habits. Kinaesthetic differentiation of the movement amplitude and force allows for a proper perception and control of movements performed in space in order to choose an optimal solution for the whole task [12, 13].

The aim of this study was to evaluate the effect of kinaesthetic differentiation during the in-run position on the in-run speed and ski jump length in a group of elite athletes from the Polish national ski-jumping team.

MATERIAL AND METHODS

The examinations were conducted in sports facilities of the Central Sports Centre in Poland, on a group of 14 elite athletes from the A and B national ski-jumping teams. Seven individuals were included in group A, while the other 7 were enrolled in group B. The mean age in team A was 22.16 years ±3.54, whereas in team B, it was 17.00 years ±1.09. Mean body mass, body height and BMI (kg/cm^2) of athletes from teams A and B did not show statistically significant differences. In team A, mean body mass was 57.75 ±2.99 kg, mean body height was 173.83 ±4.70 cm, and mean BMI was 19.08 ±0.72 kg/cm^2. These values for group B, equalled respectively: BM = 56.06 ±3.82 kg, BH = 175 ±3.94 cm, and BMI = 18.30 ±0.87 kg/cm^2. The training experience in team A equalled 12.66 ±3.37 years, whereas in team B, it was 9.5 ±1.64 years. Statistical analysis demonstrated that both groups were homogeneous in terms of training experience, body mass, body height and BMI and differed statistically only in age.

The inclusion criteria were:
- athletes from Poland’s national team A,
- athletes from Poland’s national team B,
- participants without injuries and current pain syndromes.

The measurement of the in-run position for an athlete was made using the Zebris CMS 10 device for a precise and replicable analysis of spinal mobility. Zebris CMS 10 is a device that allows three-dimensional recording of movements by means of ultrasonic markers (transmitters and reference markers) through the measurement of time between emission and reception of the ultrasonic impulses [14, 15].

The athletes were prepared by placing one triple marker set at the height of Th7–8 vertebrae and the second triple marker set behind the athlete on a stable stand at the height of the sacrum. The central unit of the Zebris CMS 10 device was positioned perpendicularly to ultrasonic markers at a distance of 100 cm from the participant, so that after adopting the in-run position by the athlete, all the markers recorded the movement (in half of the distance between the standing position and the final in-run position). The test consisted of recording the first in-run position in five consecutive trials. In the first trial, after adopting the neutral (standing) position and performing calibration of the device by the test supervisor, the athlete was asked to move to the in-run position similar to that maintained on the in-run of the ski-jumping hill. For this purpose ski-boots were used, and 2 cm inserts that mimicked the rear part of the ski binding were placed under the participant's heels. Next, the recording device was stopped at the moment when the athlete maintained the "still" in-run position and the participant returned to the initial position. Next trials of reproducing the in-run position were performed without visual control. The rest between the trials were 1 minute. After completing 5 trial in-run positions, two sets of training ski jumps were performed. The rest between ski jumps was 15 minute.

RESULTS

The statistical analysis was performed using the Statistica computer software (v.5.0, Statsoft, USA). In the "Basic statistics" module, the means and standard deviations were calculated for the analysed variables for both groups. The level of statistical significance was set at a standard value of $\alpha = 0.05$. Differences between the analysed variables were determined with ANOVA analysis of variance.

The statistical analysis led to the conclusion that both study groups did not differ significantly in terms of the analysed basic variables except for the athletes’ age. Statistically significant intergroup differences were found only for the value of in-run position in the first trial and the length of the first and the second ski jump. Means, standard deviations and levels of significance for individual variables are presented in Table 1.

Mean length [m] of the ski jump in team A was 97.16 (50.95 %) ±2.78 m for the first ski jump and 93.58 (49.05 %) ±4.23 m for the second one. The total distance of both ski jumps was 190.75 ±6.94 m. In team B, the ski jump length was 87.75 (51.27 %) for the first ski jump and 83.41 (48.73 %) ±5.77 for the second one. The total distance of both ski jumps in junior athletes was 171.16 ±9.55 m. The difference between the ski jump length of the 1st and 2nd ski jumps in teams A and B revealed that the statistical significance at $p < 0.05$ was x = 0.002 for the 1st ski jump and x = 0.002 for the 2nd ski jump (Tables 2 and 3).

Table 1. Means and standard deviations for basic evaluated variables for both groups and levels of significance

Variable	Team A		Team B		Level of significance
	X	Stand. dev.	X	Stand. dev.	
Age	22.16	±3.54	17.00	±1.09	0.004*
Body Mass (kg)	57.75	±2.99	56.06	±3.88	0.484
Body height (cm)	173.83	±4.70	175.00	±3.94	0.018
BMI (kg·m²)	19.08	±0.72	18.3	±0.87	0.179
Experience (years)	12.66	±3.77	9.5	±1.64	0.093
In-run position 1	108.28	±5.12	97.4	±6.55	0.015*
In-run position 2	106.65	±6.68	97.13	±8.00	0.064
In-run position 3	107.10	±6.87	97.53	±8.08	0.064
In-run position 4	106.40	±7.81	98.06	±7.45	0.093
In-run position 5	106.06	±8.31	98.03	±8.96	0.179
Ski Jump 1	97.16	±2.78	87.75	±5.41	0.002*
Ski Jump 2	93.58	±4.23	83.41	±5.77	0.004*
Ski Jump Total	190.75	±6.94	171.16	±9.55	0.002*

* *statistically significant differences*

Table 2. Differences in-run position for team A

In-run position	Mean	Min	Max	SD
Trial 1	108.28	99.90	114.00	5.12
Trial 2	106.65	99.50	114.20	6.68
Trial 3	107.10	98.60	114.20	6.87
Trial 4	106.40	96.00	114.70	7.81
Trial 5	106.06	94.00	102.00	8.31

Table 3. Differences in-run position for team B

In-run position	Mean	Min	Max	SD
Trial 1	97.40	91.30	107.60	6.55
Trial 2	97.13	90.00	107.70	8.00
Trial 3	97.53	88.50	107.70	8.08
Trial 4	98.06	90.70	107.60	7.45
Trial 5	98.03	88.00	109.40	8.96

The differences in absolute values between the first in-run position and other trials performed without visual control in team A revealed the following values: the error of reproducing equalled respectively: in the second in-run position: x = 1.63° (1.5%); in the third position: x = 1.18° (1.09%); in the fourth position: x = 1.88° (1.74%), and in the fifth position: x = 2.22° (2.05%).

The differences in the absolute values of the first in-run position and other trials performed without visual control in team A revealed the following values: error of reproducing in the second in-run position was x = 0.27° (0.3%); in the third position x = 0.13° (0.13%); in the fourth x = 0.66° (0,68%); in the fifth position: x = 0.63° (0.65%). A statistical significance of $p = 0.036$ was found for the correlation between differentiation of the position and the difference in the two ski jumps for teams A and B. Analysis of differences in the in-run position ($n = 14$, $p < 0.005$) and the differences in two ski jumps revealed a statistical correlation at $p = 0.036$.

Table 4. The relationship between jump length and reproduction of the in-run position

Variable	N	Level of significance
Age & Team	14	0.000746*
Body Mass & Team	14	0.493688
Height & Team	14	0.819563
BMI & Team	14	0.157273
Experience & Team	14	0.087888
In-run position 1 & Team	14	0.007734*
In-run position 2 & Team	14	0.048359*
In-run position 3 & Team	14	0.048359*
In-run position 4 & Team	14	0.091882
In-run position 5 & Team	14	0.158083
Ski Jump 1 & Team	14	0.000217*
Ski Jump 2 & Team	14	0.001747*
Ski Jump total & Team	14	0.000242*

* *statistically significant differences*

DISCUSSION

Previous analyses of the factors affecting the athlete's body during the in-run phase on the ski jumping hill, the jump phase and the flight phase (wind, position of the athlete during flight, sequence of activation of individual muscle groups in the area of lower limbs) have not provided a sufficient answer as to why, despite athletes’ similar motor abilities, similar position during the flight and a similar in-run speed, the athletes do not reach comparable results [16, 17, 4, 18]. Schwameder found that elite athletes in ski jumping have a relatively lower in-run position compared to the athletes with worse sports skills [1]. Vimavirta and Komi [6] examined the correlations between such of the ski jump as in-run speed and basic variables, such as body mass and body height, and demonstrated a significant correlation between the in-run speed and ski jump length in the first round (x = 0.628, $p < 0.001$) and in the second round (x = 0.418, $p < 0.05$), and between body mass and in-run speed in the first round (x = 0.458, $p < 0.001$) and the second round (x = 0.684, $p < 0.001$). Vimavirta and Komi agreed that the low in-run position has an effect on reduction of the forces acting on the athlete's body in the in-run position [6].

The researchers who examined kinaesthetic differentiation demonstrated that its higher level ensures a more optimal level of movement control. The effect of kinaesthetic differentiation on the level of sports performance was also found for such sports as luge, basketball, figure skating, ski jumping, Alpine skiing, canoeing, judo and wrestling [19–28].

Dolan and Grenn [29] analysed the effect of the slouched posture on the proprioceptive control of the position of the lumbar spine. They recorded a significant difference of 3.92° in the ability to reproduce the initial position after 5 minutes of maintaining the slouched posture compared to initial values.

CONCLUSIONS

In conclusion, it can be noted that in athletes from team B, lower angular deviations were observed in the in-run position, which means that these athletes were characterized by better reproduced position from 0.27°– 0.66°, whereas they adopted a relatively higher in-run position from x = 97.13 ±8.00 to x = 98.06 ±7.45 compared to athletes form team A. They also performed shorter ski jumps during the first and the second round (x = 171.16 ±9.5).

Team A was characterized by a lower in-run position x = 106.06 ±8.31 to 108.28 ±5.12 and less accurate reproducing of the in-run position x = 1.18° to x = 2.22°. In two rounds of the competition, they performed longer ski jumps (x = 190.75 ±6.94). However, it should be noted that an important factor determining the length of the ski jump is the level of muscle power of the lower limbs. In the present study, this parameter was not analysed, which can be a significant limitation.

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