

STUDY OF THE IMPLICATIONS OF THE SKI JUMPERS TECHNICAL BEHAVIOUR DURING START AND INRUN POSITION ON THE ENHANCEMENT OF THE SLIDING VELOCITY AT JUMPING HILL TABLE TAKEOFF – TRAINING STAGE II –

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Abstract: *Mastering the optimum technique is an essential prerequisite in ski jumping for achieving long jumps, flights and aerodynamically efficient as well as aesthetical trajectories - in terms of form and gesture expression. To accomplish these desiderata, it appears necessary that the jumpers are offered favourable premises at the very instant of event initiation, both for developing an increased gliding velocity at the hill table takeoff and also for developing global and segmental body posture, in order to allow the forming of the correct technical mechanisms entailed by the takeoff and flight phases, respectively. All these actions take place at the start instant during the practitioner's movement along the inrun section. The start and especially the quality of the inrun position represent teaching-learning contents towards which many trainers – especially those with lesser international experience – adopt a superficial attitude which leads to negative consequences on sportive efficiency. The present paper describes the fundamental theoretical-methodical issues of the technical contents and their way of implementation during the training process along with the didactical methodology needed for qualitative upgrading of the time sequence prior to the jumper's table takeoff instant. The objectivised assessment of the proposed methodology was accomplished through measuring the dynamics of the velocity values at the jumpers' hill table takeoff instant in terms of applying specific training means during a compact training period consisting of imitative and proprioceptive exercises.*

Key words: *ski jumping, start-inrun phase, inrun position, advanced ski jumpers, sliding velocity at hill table takeoff, specific training means.*

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1. Introduction

Execution of ski jumping events, requires a practitioner's preponderantly automatized behaviour but also exhibits several characteristics of gestural plasticity, particular features that are determined especially by the constructional parameters of each jumping hill in terms of inrun and takeoff sections design, weather factors, as well as the personalized manner of assimilating the specific motor contents.

Ski jumping involves acyclic movement type. From more a general perspective, any ski jumping, technique is, according to the practice accumulated in this field and the scientific studies performed [Baumann, 1979, Komi, Virnavirta, 2000, Luhtanen, Kiverkäs, Pulli, 2000], the consequence of the momentarily best biomechanical solution (the technique may be changed!), concretized as the sum of actions leading to an optimum motor behaviour, both economic and efficient, aimed at achieving constantly high performances (over a relatively significant time interval). More specifically, the ski jumping technique can be defined as the practitioner's skill (ability, capacity) of performing a jump with maximum accuracy in perfect safety, in terms of optimum utilization of his instantly available force, [Ganzenhuber, 2007, Balint et. al. 2009].

An effective technique is always the result of a well-adjusted motricity as well as a specially-formed physical condition [Martin, 1988, Ganzenhuber, 2008].

The style (personal manner) of executing a jump, actually means transposing into reality the individual bio-psycho-motor characteristics which assimilate and then exteriorize the generally valid contents of the technique, for a given type of jumping hill.

2. Research rationale

In accord with the mentioned theoretical-methodical considerations, during stages I and II of sportive training, the priority technical goal is the correct stabilization of the skills that are specific to the different phases which are the components of an execution in ski jumping events. Within this context, we consider that an analysis of the training process is necessary, with a special focus on the inrun phase (which is often neglected by the trainers) since:

- The quality of start and inrun phases affects the velocity of motion (gliding) during the jumper's takeoff from the hill table;
- The inrun increases the effectiveness of the developed takeoff force instant; „the failure or success of a correct takeoff is affected by the inrun position which is directly correlated with the takeoff force.”[Ganzenhuber, 2008];
- the correct inrun position favours the rotation momentum of the pelvis and the attainment of the correct takeoff angle.

The research aim is to perform an analysis - from the technical perspective – of the inrun phase in ski jumping and the methodology for the sports training - advanced group level – in order to improve technical execution on this sequence of evolution (start-inrun).

The hypothesis we departed from, is based on the following assumption:

To provide increased attention during the training process in order to achieve a correct execution (constant, stabilized) of the start and the inrun position adopted by the jumper during his takeoff from the jumping hill table, as the indispensable premise for attaining a higher motor efficiency, in terms of jump length.

3. The analysis of start and inrun techniques in ski jumping

Every jumper must start from sitting on the start bar which is present in any jumping hill structure.

Since the inrun velocity (as set by the jury through the position of the bar) considerably affects the length of the jump, the jumper must try, by using his own abilities, to increase the “inrun speed”. This can be achieved [Balint, Grosz, Gaspar, 2009] by complying with following requirements:

- A powerful push off from the start bar. The start and its succession of components, significantly contributes to the adoption of an adequate inrun position, a correct distribution of the general mass centre (GMC) in the inrun position, as well as maintaining this position when passing across the transition curve (R₁), which is decisive for a correct takeoff from the jumping hill table. A good jump largely depends on the departure from the start bar;

- “Fast skis”, optimally prepared (adequate wax, smooth gliding surface ski soles, ski tension depending on the practitioner’s characteristics etc.). The friction between the skis and snow or the synthetic/ceramic material covering of the inrun section must be as low as possible (first braking energy);

- Adopting a frontal area as aerodynamic as possible (lowest possible friction between body and air – the second braking energy). During inrun, the jumper’s position on the skis must be aerodynamically adequate and, on the other hand it must assure the premises of an explosive takeoff from the jumping hill table. The jumper can adopt such a position only if he possesses a special mobility/suppleness of ankles, spine and hip joints thus creating favorable premises for pushing his trunk forward.

The inrun position must be decided individually, in accord with the anatomical constitution and the other characteristics of each jumper. This aspect is very important especially in the case of children’s and young sportsmen’s training process, in general.

At this level, any imposed and/or unnatural position should not be recommended.

The main actions/characteristics of the inrun position are:

- The chest is leaning over the thighs;
- The trunk is straight and almost parallel to the skis;
- The head is lowered, the glance is directed forward in order to visualize the inrun tracks (“long neck”);
- The arms are de-contracted at the shoulders and placed alongside the body, stretching backwards – parallel to the skis – palms upwards, fingers stretched out;
- The knees apart, at shoulder width distance and pushed forward beyond the toe tips;
- The jumper’s weight is equally distributed on both legs and over the entire sole thus attaining a balanced position on the skis;
- The skis are settled on the entire sole (thus minimizing the frictional drag), the distance between the skis being determined by the inrun tracks on the jumping hill table. If there are no tracks, the distance between the skis will be adopted so as to be approximately equal to a palm’s width.

The inrun position is maintained inclusively when passing through (entering) the first section (R₁) of the jumping hill table.

The centrifugal force exerted here must be compensated by the legs and trunk musculature (“early straining”).

During the inrun phase, the jumper tries to attain maximum velocity or respectively, to convert the potential energy of his body into effective kinetic

energy (through the adopted inrun position, skis arrangement and preparation).

If we assume that a jumper has a 100% potential energy just before the start instant, his kinetic energy during the inrun phase will normally amount to 88% while the remaining 12% is lost due to friction (in skis and the jumper's frontal cross-sectional area) as well as to other variables (quality of skis and ski suit, quality of waxing, air drag, start technique and actions during the inrun phase).

By means of an energetic and well-executed start, the jumper may attain an initial (departure) velocity of 4m/s which can increase the final velocity by 0.3 – 0.4 m/s. Reichert (1980) proved, using mathematical calculations, that the final phase of the jumper's evolution on a K70 jumping hill may result in a performance increase by about 3 – 5 m.

4. Organizing the research

The research subjects were the members of the national sports group B (four sportsmen) aged between 12 and 14, respectively: T.R. – born 1996, T.E. – born 1997, P.I. – born 1997 and B.S. – born 1998.

The research was carried out throughout the entire length of the preparation period which took place in Villach (Austria) between 00.09.2010 and 15.09.2010, at the Alpen Arena complex – the 60 m K jumping hill.

5. Methodology of experimental activity

During the preparation period, the subjects completed three training sessions/day (over a period of 7 consecutive days) of which daily, the first training, was intended for activation (7.00

– 8.00), while the other two were specific trainings (10.00 – 12.00; 15.00 – 17.00).

During the specific training sessions, the section dedicated to specialized physical training (rapid force development, proprioception, ideomotor training etc.) was followed by a series of 8 jumps/subject from the K 60 jumping hill / training session (a cumulated 16 jumps/day). During each lesson, the first jump was intended for familiarization, while the second lesson was focused on training, the start and inrun position improvement which resulted into superior velocity at leaving the jumping hill table.

The imposed execution conditions entailed the shifting of the start bar to position 16 (throughout the duration of the research – valid for the second jump), while the skis of the involved jumpers were not subjected to any previous preparation so as to ensure identical training conditions for all executants.

The most significant errors caused by the motor behaviour during the start-inrun phases of the second jump/training session – were recorded by two trainers using individual observation cards [Epuran, 2005]. Table 1 provides a centralized overview of the initially observed technical execution errors for each jumper, their implications on the derived motor efficiency and the initials of the performing subjects' names.

The value of the hill table takeoff velocity was measured using the equipments of the sports facility referee tower, employing an ISF homologated velocity meter with digital display.

At the end of each day of training, the four jumpers, watched their filmed performances – during the second jump – including a still frame with the velocity meter, while the trainers analyzed the individual errors occurring during start-

inrun execution (after having previously watched the same recordings and agreed on the most significant errors/jumper), their causes and the solutions for improvement particularized/jumper for the future activity.

Every day, the trainings were preceded by 2 – 3 sets of initiative exercises focused strictly on enhancing the technical mechanisms involved in achieving the start

and inrun positions, in order to eliminate the ascertained technical deficiencies. The applied means are presented in Table 2.

The values of the gliding velocities at hill table takeoff obtained by the four investigated jumpers (over the entire training period – second jump) as well as the corresponding plots are represented on Graph 1.

Table 1

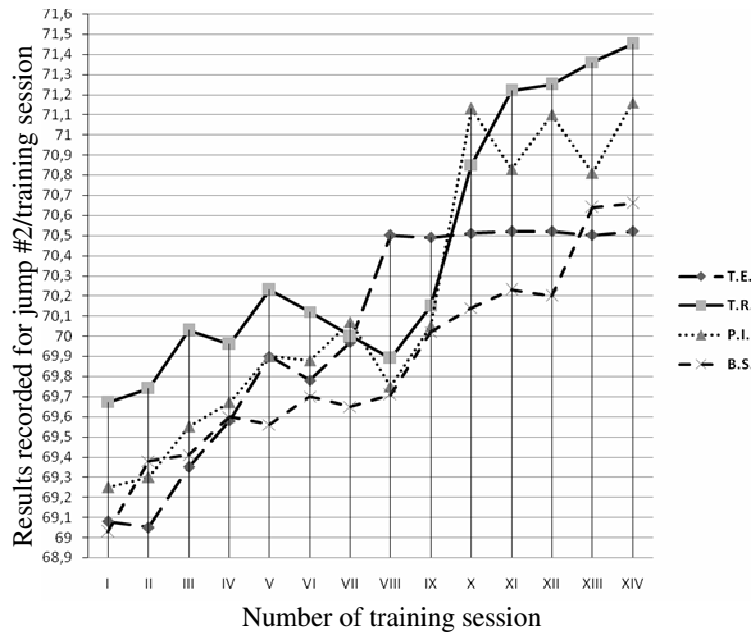
Synoptic table showing the most significant technical execution errors ascertained with the members of the national group B during the start-inrun phase in ski jumping events (09.09. – 15.09.2010)

Start phase (1)	Major execution errors
	A.1. Sitting up from the start bar and abruptly changing into inrun sitting position (the knees not far enough forward pushed, trunk insufficiently stretched, in this case the GMC is often shifted to far to the rear).
	B.1. Controlled sit-down into inrun position – knees are pushed forward but in most cases, the trunk is insufficiently stretched – occurrence of „short neck” characterized through „insufficiently stretched back of head”. Since it refers to a seating which requires much more time for execution, due to velocity gain along the first meters after start, the jumper is unable to control all of his body segments for an adequate distribution of the GMC.
	C.1. Sitting up and sitting down on relocating the stretched trunk forward – in this case the knees are not far enough forward pushed, GMC incorrectly located resulting into a raised inrun position causing loss of gliding velocity as well as an insufficiently sharp angle, as is needed at takeoff instant. The jumper tries to maintain his GMC by excessively lifting his arms and chin.
	D.1. Sit-down with knees too far apart (thighs are not parallel); the pelvis drops into R1, the GMC is back shifted. Excessive pressure of upper train on lower train.
Inrun phase (2)	Major execution errors
	A.2. Incorrect distribution of the GMC from sitting down for inrun position.
	B.2. Losing correct GMC distribution at R1 – insufficient strain in lower limbs.
	C.2. Insufficiently stretched trunk – „absence of long neck”.
	D.2. Arms lowered, raised or not extended.
	E.2. Extended or too lowered head.
	F.2. Glance too low or too high on the inrun track
	G.2. Insufficient crouching in inrun position.

Table 2

The means (imitative exercises) applied between 09.09. – 15.09.2010 for enhancing the technical behaviour during start and inrun

Start – inrun Phase	Initial execution errors / 09.09.2010	Initiative – corrective exercises for the inrun position (code P.e.)
T.E.	A.1. A.2. B.2. C.2.	<p>P.e. (1) – sitting on a small bench, face to wall, abruptly sitting down in inrun position – raising, followed by controlled re-seating simultaneously relocating forward both knees and the stretched trunk, stretched neck; attempting to touch the wall with the top of the head (as reference for distinguishing between faulty and correct seating for the inrun position);</p> <p>P.e. (2) – sitting down for inrun position on the platform of the balance apparatus, observing the correct MGC distribution;</p> <p>P.e. (3) – sitting down on the velcro mat in inrun position (proprioception);</p> <p>P.e. (4) – integrally imitative exercises – from the small bench transition into sitting for inrun position – keeping steady, followed by takeoff, practitioner is caught by his partner, above head, lowering and landing in Telemark position;</p> <p>P.e. (5) – from a small bench placed on a ramp (covered with asphalt or concrete), feet placed on the trolley, start and sitting into inrun position, maintaining it for 10 – 15 m (this exercise allows several repetitions before fatigue occurs);</p> <p>P.e. (6) – while moving on the trolley for takeoffs, sit-downs – re-sit-downs in inrun position (similarly with roller skates with in-line rollers or shortened roller skis);</p> <p>P.e. (7) – proprioceptive training, exercises P.e. 2 – P.e. 6, will be performed with eyes closed;</p> <p>P.e. (8) – From inrun position, descents, knees moving apart and closing – observing that the trunk is permanently parallel with the ramp slope (the exercise can be carried out using the takeoff trolley, roller-equipment skis or roller skates);</p> <p>P.e. (9) – inrun position → trunk stretched, neck stretched (exercises on various balance devices);</p> <p>P.e. (10) – from standing, inrun position on applying different pressures, exerted on the practitioner's trunk by his partner; the same while moving along with the takeoff trolley, roller skis, in-line roller skates (observing that the trunk is kept in the same position);</p> <p>P.e. (11) – using jumping skis, downhill descents with inrun position on differently sloped synthetic tracks while conscientizing the correct/incorrect GMG distribution, during the execution the stress will be laid on distributing body weight over the entire sole area, when passing through curve R2 of the landing area).</p>
T. R.	D.1. A.2. C.2. E.2.	
P.I.	C.1. A.2. D.2. E.2.	
B.S.	A.1. A.2. B.2. D.2. E.2.	



Graph 1. Gliding velocities at takeoff

6. Research data interpretation

On applying the system of corrective means for efficientizing the technical execution of the jumpers during the start-inrun phase and based on the recorded data, following progress rates (R.p. %) of the gliding velocities/jumper at jumping hill takeoff were obtained (R.p. = final testing – initial testing / initial testing x 100):

$$\text{T.E. } 70.52 - 69.08/69.08 \times 100 = 2.08\%$$

$$\text{T.R. } 71.45 - 69.67/69.67 \times 100 = 2.55\%$$

$$\text{P.I. } 71.16 - 69.25/69.25 \times 100 = 2.76\%$$

$$\text{B.S. } 70.66 - 69.03/69.03 \times 100 = 2.36\%$$

Although the progress rates expressed as percentages seem relatively insignificant at first glance, the absolute value differences between the gliding velocities at takeoff from the jumping hill table (first training session) and the final values/jumper (obtained after the last training session) show a significant increase of this parameter, as follows:

$$\text{T.E.}, 1.44 \text{ km/h} = 0.4\text{m/s};$$

$$\text{T.R.}, 1.78 \text{ km/h} = 0.49\text{m/s};$$

$$\text{P.I.}, 1.91\text{km/h} = 0.53\text{m/s};$$

$$\text{B.S.}, 1.63\text{km/h} = 0.45\text{m/s},$$

which, correlated with the jump length, and neglecting other variables, should represent a performance increase by about 4 – 5 m.

The velocity values obtained during the last 4 training sessions show a flattening trend in data dynamics (see Graph 1, sessions XI – XIV), for all the members of the group, which signals a process of settling of the specific technical behaviour, more obvious and earlier in T.E., slowly increasing – still – in T.R., fluctuating in P.I. and more delayed in B.S.

After completing the training period, for the studied technical component, the following remarks / jumper were formulated, which should be considered in future training activities:

T.E. → insufficiently stretched trunk (C.2.);

T.R. → insufficiently stretched trunk; (C.2.);
knees excessively wide apart (D.1.);

P.I. → incompletely crouching position (G.2.);

B.S. → head in extension (E.2.).

7. Conclusions

The quality of the start and inrun position (or, respectively, the correct GMC distribution during gliding along the inrun track) in ski jumping, are significant factors in generating superior velocities at the jumper's takeoff from the jumping hill table and favourable premises for maintaining the takeoff force, achieving a correct takeoff angle, favoring the rotation momentum of the pelvis, all these with obvious repercussions on the length of a jump.

- The execution technique of the inrun position is particularized depending on the somatic and psychomotor characteristics of individual jumpers. Also, during the training process, the height of the start bar as well as the variable slope of the inrun track (determined by the constructional profile of the jumping hill), demands trainers' actions aimed at educating the jumpers into evolving a specialized, complex kinesthetic sense, regarding their quality of adaptability of actions composing the sit-down sequence and maintaining optimum inrun position.

- It is recommendable that any execution errors occurring during the technical training activity of ski jumping be presented in terms of causes generating these errors so as to provide the most pertinent solutions. In verbal interventions addressed to the jumper, no more than 2 -3 major errors / execution should be presented for pre-established training objectives.

- Due to the specificity of ski jumping training (wherein the number of integral repetitions is limited by objective factors and the execution time of the event is short), initiative exercises and proprioceptive training play an extremely important role in settling the technical skills and forming a correct body schematic both in static as well as in dynamic modes. This kind of means is applied necessarily before the beginning of the actual jumping hill training then again and in a differentiated manner over the training period (in order to increase the degree of awareness of the technical

training requirements and jumper activation) and, in some cases, even after completing the training session, in order to settle/correct the motor behaviour as well as anticipatively motivate the jumper for the next training sequence.

- The results of the research have shown that only a relatively short period of time is necessary for enhancing an essential technical component to increase the sports efficiency of ski jumping, if a didactically adequate methodology is applied.

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