Biomechanic analysis on the slalom turn speed with top skiers

Aziz Dujaka and Zenel Metaj*

Summary

Skiing is accomplished under special racing conditions, including environment (tracks, trails), which has specific characteristics. Studying the techniques of alpine skiing is difficult to be realized under laboratory conditions, therefore the research should be accomplished in conditions that are defined by the environment or the race tracks. In order to determine the effectiveness of the slalom certain passages of tracks which differ in features in slalom races were selected. In order to have accurate recorded data that represents the slalom technique, speed was selected as the most important biomechanical parameter that characterizes the cinematic space of alpine skiing. With the analysis of the results and statistical processing, the conclusion is that the speed in given stages of the curve of slalom changes.

Keywords: Carving skiing, skier, skiing system, kinematic parameters, speed, acceleration.

Introduction

In recent years, biomechanical research has been orientated in the direction of determining the kinematic parameters (space-time) that allow defining a computer simulation and the modeling of ski movements through animation.

Depending on the realization possibilities of the biomechanical analysis of the elite sport technique which is applied by top sportsmen, sportsmen's involvement in the research lab is not enough.

Aziz Dujaka, Faculty of sport science. Prishtina University, email: azizdujaka@hotmail.com.
Zenel Metaj, Faculty of physical education and sports. University of AAB Prishtine, zenel.metaj@aab-edu.net

It is possible that the compensation of laboratory research with representative samples to be partly fulfilled by the use of television footage of races of the best sportsmen.

This enables the realization of future research in determining the efficiency of the movement structure of a respective sport.

The problem dealt with in this paper is the skiing technique in alpine disciplines, particularly the slalom technique. This problem is observed in the environment which is difficult for precise observation and tracking, and which will not make the realization of the application of their direct measurements easily fulfilled.

The general aim of this research is defined by collecting the results of speed values during specific phases of the twisting slalom.

Methodology

The sample of this research are top skiers, Jean-Pierre Vidal-FRA, Sebastian AMIEZ-FRA, ALAIN BAXTER-GBR, winners at the slalom races in the XIX Winter Olympics Games, in Salt Lake City, in 2002.

In this research the first slalom race for men on the tracks of the Deer Valley Resort track is taken into consideration. The starting point was at the height of 2488m and the finishing point was at 2274 m (with a height level difference of 214m), and 58 gates being located by coach Jesse Perkins (USA). 78 contestants participated in the race.[1]

As an analysis sample of the situational motion, passage IIIa-skiing on the widened tracks through 2 open gates (gates 20, 21) is taken into consideration.

The initial time was 15.76 seconds (sec) and the final time was 17.60 sec (a 01.84 sec difference) of the movement analyzing stage describing the movement from the left side (positions 410-418), right side (418-438), and left side again (438-454). The final time of the first race was 0:48:01sec.

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[1]Results of slalom *competitions* for men in winter Olympic Games L.O. winter Salt Lake 2002, at: http:// www. eurosport.com/Olympic games/Salt Lake 2002/schedule results/Alpine Skiing/htm
(vizituar: 20.12.2013).

The parameters (variables) of kinematic space which are studied in this research are the speed(v), which derived from the covered track (s) for the time(t) and acceleration (a) of the points of gravity of the system skier-ski (TAS, TCR, TCA) in the horizontal direction (x), the vertical direction (y), and the straight direction (A):1.V-TAS –x, 2.V-TAS –y, 3.V-TAS –A, 4.V-Tcr –x, 5.V-Tcr –y, 6.V-Tcr –A, 7.V-Tca –x, 8.V-Tca –y, 9.V-Tca –A.

In order to analyze the recorded material, a program (AKB-SKI) for kinematic analysis of the biomechanics research of television footage modified for alpine skiing (in the cabinet of biomechanics at the Faculty of Sport Sciences in Prishtina) was compiled.

After selecting specific stages of experimental movement, the material was recorded through the system Aver Media (TV Series Software Fleet-Support Windows 2000). For determining caliber constants, the real size (180 cm) of the poles in the gates in the given positions was used. This condition enabled us to use the program MGI Photo Suite (version 4.o, Support Windows2000).[2]

Grafikoni 1.
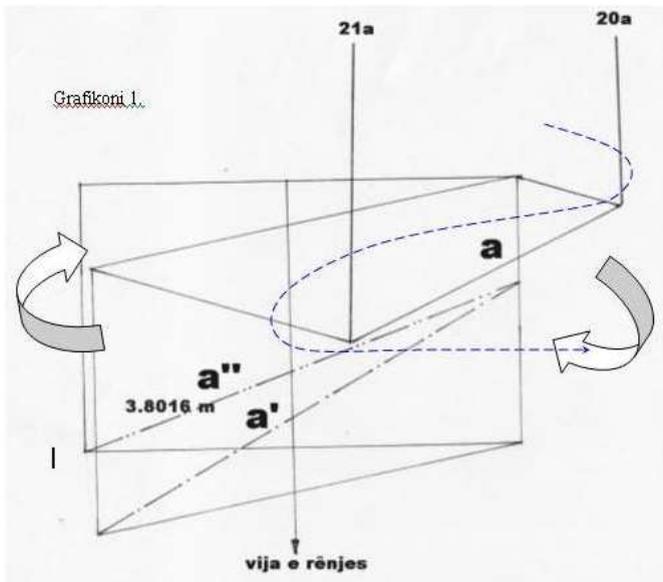
[2] APAS, Ariel Performance Analysis System User's Manual, 1995

With this program, the given position may be reduced or increased so that the caliber size always has the same value (size) and also the order of positions in relation to real natural ratio can be done.

(Graphic 1).

Findings

In processing the results and in discussions Speed(v), the final track(s) and acceleration(a) passage III -a of the skier Jean-Pierre Vidal-FRA is included.

The maximum values of the kinematic parameters results are achieved at the end of the main stage where the track(s) takes longer on the same interval of time and with this the speed in flat tracks (VA) with the rate 10,134 to 11,490 m / s, and the average from 6056 to 7205 m / s is achieved. Compared among the rates, the center caudal rate (TCAs) has full speed (11,662 m / s) then the total alignment pivot (aggravation) (10.360 m / s), and finally the cranial part (9.845 ms).

The horizontal speed (vx) of the same pivots of alignment of the skier-ski system does not differ significantly from the skiing speed on flat areas and has the approximate value. Contrary to this, with vertical speed (vy), the alignment pivots of the skiing- skier system moves (rises) vertically when out of the current turning and moving to the new curve at a time when the action from ski to ski shifts, and the direction of the movement changes. Most of the vertical part of the track is passed by the pivot of the caudal part (TCAs) 0.398m, then the cranial part (TcrS) 0367m, and less by the general system pivot (TAS) 0.329m.

This report covers their vertical speed (vy), 4,109 m / s (TAS), 4588 m / s (TcrS) and 4.976 m / s (TCAs). The given results deal with skier `20.A. Baxter-FRA (POSITION- II place), while the results of skier positioned on the 1st place in slalom races (3. Vidal_FRA JP) have larger values of statistical parameters, which show the impact of the movement stage after crossing the gate 21a, as analyzed positions do not represent true value of caliber constant for these positions. Observing the same skier in the movement between the gate 20a-21a,

the results obtained in lower values because he reduces the speed of sliding in order to get closer to the stick of the Gate (especially to Gate 21a), which he actually does. (Chart 1, Diagram4).

Table1. Basic statistical parameters of kinematic parameters

Speed –v (m/s), passage –IIIa (3. J.P. VIDAL – FRA)

No.	Variables (N=22)	Men	Min	Max	Varia.	S. Dev	S.Eror	Skew.	Kurt.
1	V-TAS –x	7.045	0.054	21.682	46.614	6.827	1.456	1.253	0.108
2	V-TAS –y	1.610	0.000	4.8.44	1.768	1.330	0.248	0.909	0.165
3	V-TAS –A	7.560	1.416	21.682	42.424	6.513	1.389	1.296	0.163
4	V-Tcr –x	7.045	0.054	21.682	46.614	6.827	1.456	1.253	0.108
5	V-Tcr –y	1.6100	000	4.844	1.768	1.330	0.284	0.909	0.165
6	V-Tcr –A	7.560	1.416	21.682	42.424	6.513	1.389	1.296	0.163
7	V-Tca –x	7.615	0.544	21.978	47.705	6.907	1.473	1.223	0.065
8	V-Tca –y	1.722	0.000	4.463	1.623	1.274	0.272	0.579	0.596
9	V-Tca –A	8.250	2.408	21.978	42.020	6.482	1.382	1.320	0.176
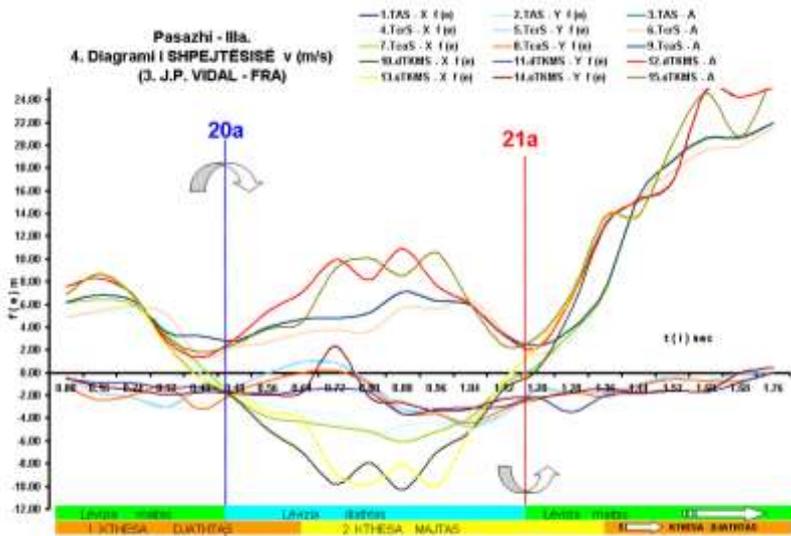
Acceleration (a) of the representative pivots of the skiing- skier system (TAS TcrS, TCAs) and front heads of the ski lockers (dTKMS, sTKMS) rotate depending on the reached speed. Mainly, the accelerated speed appears in the first stage, taking the curve with a value of approximately 60m/s2 value for the gravity pivots of the
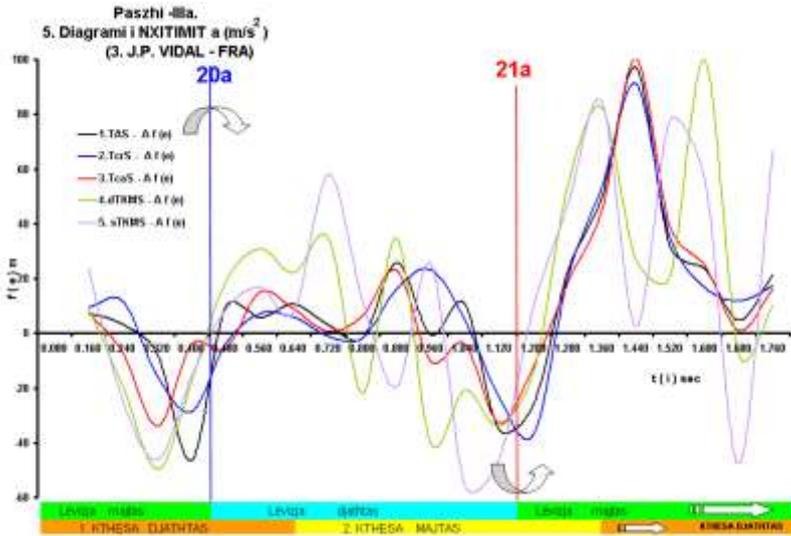
skier- skiing system, while skis reach their maximal value of accelerated speed of 96-99m/s2. The rush of speed is worth something less than 33,307 to 71,268m/s2(TAS TcrS, TCAs), while the skiing has a value of 57727-123218m/s2.(Diagram5).

Speed acceleration is shown in the first stage of the curve and at the beginning of Stage III of the curve. In Stage I the acceleration is evident, depending on the offload of the skies; firstly the higher part by transcending the ski-skier-skiing system from the outer part of the ski as a capacity of the leg pushing, a movement which is reached by contraction of the extensor muscle of the knee joints of the femoral bone and, as much as possible, of the talocrural.

This acceleration is increased by using the ski poles. In Stage III, acceleration depends on external forces, especially the tangential

component of the force when the opportunity of ski rotation in the direction of greater slope is possible. In slalom races this stage is very short, compared with the great slalom (quite long) that significantly affects the final speed (reached time) in the final slalom carving ski races.

The speed slowdown appears at the end of Stage III (exit from the curve)-in other words, moving from one curve to the other. "During this move in all tests which have measured the speed in the curve, a low speed was achieved".[3]

Two key indicators influence the velocity decrease:
    -During the upward movement through sliding sides, an increased pressure of the supporting surface is induced.
    -Skis can be positioned on their edges when they are located in a wider angle and are positioned on the sides of the next turn, which has a new, but relatively large and controlled pressure.[4]

To have the upward movement and skis on their edges, more time and a wider space between the gates will be needed. Contestants solve this difficulty with one move. They relate the beginning and the end of the turn with one action. At the end of the turning, using lateral movements, the competitor uses his knees to turn the skies from one side to the other side from the center of the overall body weight.

This is the novelty of the lateral motion of the knees. The motion grows depending on the inclination of the slope. Following that movement, extension of the limbs on its sides is realized, which helps to unburden the skis before the skier takes the next turn. This reduces the need for vertical motion because the skis have already been set in the correct position for the fall line since the beginning of the turn (curve). This movement aims the easement of the skis through a lateral movement of the knees.

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[3] Milan Zvan, et al., *Alpsko Smucanje,* Institut za sport, Fakultet za sport, Univerzev Lubljani, Ljubljana, 1996.

[4] Kresimir Petrovic et al., *Po Rokovih smucinah.* Ljubljana: Paralele,1992.

Assigning the shortest route over the trail in alpine ski races. After reviewing the forms, phases and especially the structural elements of the basic movements of alpine skiing, there is a need for defining the shortest track (trail) for the movement of the skier system, presented with the general center of its gravity and ski tracks during the skiers skiing through the gates and endurance of the complete ski trail. Depending on these two trajectories, speed plays a crucial role in the movement (slip) of material points of the system, therefore it should be optimal.

The trajectory of the movement of the overall weight of the skier-ski system (TAS) passes a shorter route in the horizontal flat surface(x) compared to the ski trails on the same flat surface. Carving skis with the pointed side arch (side bow) enables this, because it ensures a lateral curvature of the body during the curve, which is needed to deal with the radial force encountered during entry into the curve. This is particularly evident in slalom races because it allows the skier better chances to bow sideways more, which results in the reduction of the skiing route and in achieving the best final time in the race.

Conclusions

After setting parameters in this paper, it may be concluded that Speed (v) of skiing is the most accurate efficiency guide for the carving ski slalom. Slalom speed skiing in curves increases or decreases, depending on the specific part of the curve. In the part where the skiing with breakage directions happen (Phase III), speed decreases, and during ski discharge (Phase I), the speed increases. The skiing profile in the turning slalom is 10-15 m/s . The amplitude of the movement of the center of the body weight in the vertical direction allows discussion about shorter skis with more pointed lateral edges (Carving Type), which enables optimal pushing of both skis, as it is important that both skis are in contact with the snow at all times.

The open (wide) position of skis is necessary and has a double function. Firstly, this way of skiing enables the skier that with higher speed and easiness bends sideways with a larger scale of balancing

position; and, secondly, it ensures a balancing position of the skier with the possibility of affordable distribution of the body weight onto both skis, the outer and inner ski.

The ski shape is noticed when conducting the turning (curve) stage without pressure and during a greater pressure, which enables a smaller ski sliding with the back part of the skis during the exit from the turning curve. Maintaining optimal speed characterizes all curve stages. This speed is held, up to the moment of its decrease, while using the knee on the lateral side of the inner part of the ski. This ensures skiing on the complete ski surface for the best possible finishing entrance. Turning is accomplished by being faster and closer to the gate poles. Therefore, skiers do not use edges of the skis between the two gates, which enables speed reduction. The curve is turned within a short period of time (optimal period of time) close to the gate, so the skis between the two gates without using the ski edges enable a better speed.

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