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Kinematic Research of Improvement the Fact that Shorter and Direct Skiing Line Achieved Higher Speed While Passing Thought Slalom Gates

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Abstract
Kinematic analyzes in this research is aimed to determine are the competitors with shorter skiing line achieved higher speed while passing thought slalom gates. In the first part of research it was discovered that the competitors who had the shorter skiing lines in the first curve, as a rule, had the longest skiing lines, in the second turn. Based on the analysis improved in here, is possible to see that it is very hard, maybe even impossible, to ski in a way where the skiing line is very short during the next few curves in row.
The second part of research is aimed on making correlation between skiing path and the skiing speed on the chosen sample in the measured space (two slalom curves).

Key words: **alpine skiing, kinematics, skiing speed, skiing trajectory**

Sažetak
Kinematičkom analizom pokušalo se utvrditi jesu li natjecatelji s kraćom linijom skijanja postizali veće brzine pri prolasku kroz slalom vrata.
U prvom dijelu istraživanja otkriveno je da su natjecatelji, koji su u prvom zavoju imali najkraće linije skijanja, kao po pravilu, u drugom zavoju imali najduže linije skijanja i obrnuto. Na temelju tih, dobivenih, analiza, može se utvrditi da je vrlo teško, možda čak i nemoguće, skijati na takav način da je linija skijanja vrlo kratka u nekoliko uzastopnih zavoja.
Drugi dio istraživanja usmjeren je na uspostavljanje korelacije između putanja kod skijanja i brzine skijanja na izabranom uzorku u mjerenom prostoru (dva slalom zavoja).

Ključne riječi: **alpsko skijanje, kinematika, brzina skijanja, trajekorij skijanja.**

Introduction

American biomechanics' professor, ski instructor and coach, Le Master (by:Lesnik at al.1999) says: alpine skiing is sensory sport. We like what we feel when we see another skier performing a big turn on skis. And what is it you feel? Force. The force of the earth's gravity and the momentum given by snow, allow skiing. For these forces, shaped skis as they are formed, and our body moves and turns as you move. When a skier realizes the effects of these forces on him and skis, and placing it in specific positions learn to use the influence of forces in conjunction with the skiing gets more sense.

The assumption is that the best skiers who decide and determine guidelines for the development of techniques of alpine skiing, the best define the methods and apply opinions given by ski instructors. Task of skiing experts is to form new settings offered by the top competitors. The manner in which they skied led to the best results.

Typical characteristics of the position in the competitive skiing are in order: open ski position, knees pushed forward, the upper body is partially bent and arms pushed forward. Only candidates who are physically very well prepared, they are able to ski in this position at high speed. Good distribution of weight on the skis in turn the entire length of force depends on the balance of the center of body gravity in relation to the skis center (relative to the front, rear and edges of skis). In the competitive alpine skiing slightest possibility shifts the center of weight in the vertical direction is of great importance (Kovač 2004). Consequence is adequate, displacement as well as the possibility of maintaining prolonged pressure on the skis sliding surface.

Speed skiing in slalom competition

By changing the direction of movement on the edges and achieve the same length of turns, speed skiing increases from curve to curve. Because of fear and insecure, skier attempts to control the speed by the lateral deflections as it is allowed by doing vertical and lateral movements.

Authors such Rajtamajer and Gartner, are convinced that the high quality standards of turn are based on the importance of the last part of the turn. Turn length is expressed rapidly as skier sets skis on edge. Speed skiing must be regulated by skis rotation along or across the fall

line. Shorter skis phase rotation is better controlled skiing speed. During skis rotation along or across the fall line, sliding sideways still takes place in some turns.

Skiing line choice between the gates

As noted above, several factors affect the success in alpine skiing. Among them is the line of skiing that is more or less direct, with maximum speed and that has to be under load. In every sport, athletes develop as individuals did not base on pre-developed and established program, nor alpine skiing is no exception. Of course, it often happens that the established work program and its effective implementation are separated. In this case, the program must be modified and adapted to new circumstances dictated by the relationship of the program and participants. First, young athletes need to learn proper technique that improves over time until they reach a peak performance (Hintermeister et al.,1995). Later, the priority of training techniques in the first place should be the development of the best possible ways of skiing while maintaining the highest possible speed skiing. During the skiing speed is changed, and the task of competitors is to maintain an optimal balance between the increase and decrease speed (Kugovnik, Nemec, and Supej, 2005).

The problem in this study represents a dilemma whether shorter line provides skiing and skiing fast through the gates? Does skiers whose ski more in direct line to the entrance of the gate keeps the speed skiing or even increases. Are the shorter and more direct lines of skiing requiring achieving higher speed and better results? Is this way of skiing is possible throughout the length slalom races or just in certain segments, remains an open question for analysis.

Methods

Respondents were alpine skiers who were actively competing in alpine skiing, Ski World Cup - Slalom. Characteristics of slalom techniques have been studied based on kinematic measurements recorded during the 2004 season at the World Cup slalom in Kranjska Gora sample consisted of 18 competitors at the door numbers from 2 to 69, only those who are, according to experts, skied through the gate without any visual or obvious differences that could affect the result in the measured area, are included in the final kinematic analysis. This allows the consideration of all the competitors from the slalom rankings, which competed 2004 at the FIS World Cup. Data for this research is partially taken from research by Lešnik (2007) And the given information are reanalyzed and further clarified.

Data Analysis

The images were analyzed with the program for kinematics - biomechanical analysis (APAS system for kinematic analysis). After kinematic analysis, data were analyzed by statistical program SPSS, using the Description statistics to calculate the average speed and the average gradient of the slope in the measured area, as well as Pearson correlation analizes.

This way of processing data provided the coordinates of the points that mark the ends of the segments in the measurement space - X and Y.

Based on the distance of a point position of the right and left ankle (stat. mean) for each contestant calculated the average distance of the fall line skiing line ($y = 0$) in the measuring area, and measuring the space consists of two slalom turns. Analysis to determine whether there is a similarity between the skiing lines at poles (gates) first and second poles of each competitor, or whether there is a difference within the skiing trajectory lines.

According to the experiences of other scientists came a conclusion that the assessment of the performance of skiers is successful only if analyzed two turns in row of slalom race.

Slalom competitor trajectories variables

Start a new turn and the end of the previous turn is defined by the measured area for each competitor by the time or place of transition skis path (mean left and right ankle) and orbits the center of gravity of the skier's body. Crossing skis path represents the mean of the path of the left and right ankle in two phases, which are part of the full scale space positioned in the first run. The average distance of a skiing line from the point $y = 0$ (fall line) is calculated based on the distance of all points in the skis path..

Calculating slalom competitors average speed variables

Calculate the average speed of competitors (mean ankle) is measured in the measured area in slalom course during the competition. Average rate calculated is based on the absolute velocity of competitors - from the first poles, located in the measuring area, crossing the path of the skis and the center of the body (change of the edges), and to the other end of the stake. Based on the absolute velocity in the above paragraphs, calculated the average speed for each contestant measured segment (Vavg). The average gradient of the slope in the measured area was 21.46% $\pm$ 2%.

Results and discussion

It should be noted that the data obtained for each line skiing slalom result of the arithmetic mean of the position - the ankles distance position, when a skier starts to turn to the stake, which is located in the measuring segment. (Supej at.al.2004).Different distances between both skis are more or less distant outside ski, too often can have an impact on it. The above mentioned data therefore can serve as

support in the further analysis. The relationship between the distance to the poles and away from the other poles, it was established whether the distance line skiing individual competitors from the first stake, and the second stake of approximately equal (Božič,2005). This means that the competitors whose lines were closer to the first ski pole were generally more away from the second pole. It should be noted that the competitor bib number 2 has skied at a minimum distance from both poles in relation to all the competitors who represent a sample of this research. Its average distance from the y-axis to the first and second stake is 3.05 m, the average is calculated based on the results of kinematic measurements. Competitor bib number 32, who skied nearest the first pole and furthest second stake, has an average distance from the y-axis (fall line) slightly higher and it is 3.13 m this average is also calculated on the basis of the results obtained.

After examining the results visible is negative correlation (Pearson correlation coefficient of -0.256). This means that the competitor who have been away from the y-axis on the first pole, in most cases, were much closer to the y-axis on the other pole, and vice versa. A typical example is the competitor bib number 32, whose line was the closest to first ski pole and farthest from the second pole. At the same time, it should be noted that there is no competitor who had a very short line of skiing to both poles in the measurement space. No one competitor is not very far from the point 0 (y-axis), as compared to both poles. The question that is posed in the problem of that, is it possible to ski that way about several consecutive gates is somewhat or so appropriate. It can be argued that means in the slalom is impossible to talk about the ideal skiing line and that the optimal skiing line is one that guarantees the minimum loss of racer's speed.

Table 1. The correlation (relationship) between the distance from the line of competitor's skis from y– axis at the first and second pole calculation.

Correlation		Distance from the first and second pole
Distance from the first and second pole	Pearson correlation	- 0.256
	Sig. (2-tailed)	0.304
	N	18

Distance to the stake and the stake of the second distance from the middle of the ankle length axis - y in the first and second pole (meters) Pearson correlation coefficients correlation Sig. (2 - tailed) statistical significance of the correlation coefficients N is the number of respondents

Explanation of the table:
Speed / AVG calculated values of correlation coefficients and statistical significance of speed skiing in measuring segment

Line / AVG calculated values of correlation coefficients and statistical significance of the lines of skiing in the measuring segment Pearson correlation coefficients of correlation value

Sig. (2 - tailed) statistical significance of the correlation coefficients

N number of respondents

Table 2. Average speed and average length of two turns in the measuring segment correlations

Correlation		Distance from the first and second pole
speed/ AVG and skiing line / AVG	Pearson correlation	-0.551
	Sig. (2 – tailed)	0.018
	N	18

On the objectives basis set out in the paper or whether competitors who choose the shortest line between the ski gates of higher speeds, it slips away or ski faster between the slalom gates and achieve the better result at the end of the race.

In addition, the aim of this paper is to determine the kinematic analysis of the difference in speed skiing for athletes with a shorter skiing line trajectory track and longer lines of skiing, or to possibly prove that it is not necessary that the shorter trajectories through the course and the fastest path skiers move the speediest in the slalom competition.

Skier whose ski more direct line to the entrance of the gate keeps the speed of skiing or even increases. In this case, the optimum orientation of slip can be preserved by only physically strong competitors with perfect technique. Fast-changing angles of direction and entering the gates on properly installed skis enables the creation of a short line at the next gate. (Matijevec, 2003). Consequently, the speed and the short line of skiing cause increased pressure at skis when creating curves. When the specified pressure is too strong, the competitor must reduce skiing speed (Lešnik, Žvan 2010).

Shorter trajectory lines of skiing a smaller distance or short path skiers from one gate (in the measured area) represent an important parameter in the study of ski technique. A condition that must be met is that the competitor must, if it wants to do a proper turn, a change of angle - direction of movement, weight transfer and set "new" skis to turn. It should be noted that they will achieve greater centripetal acceleration if we have a short trajectory line of skiing at the same speed. Modern competitive techniques, shorter skis with pronounced lateral curve enabling these requirements. So all need to be aware that when making such

turns achieves elevated pressure between skis and snow, resulting in a higher reduction rate at the exit of the turn. Therefore, we are faced with the dilemma of how we need to set the skis in a curve to achieve speed and consequent success in competitive alpine skiing. The focus of the work on the part of the movement included in the training process is closely related to the tactics used in the competition (Supej and Černigoj, 2006) and skiing these parameters, as well as likely in other sports.

Different studies tell that several factors affect the success in alpine skiing, in this case the slalom race. Among them is the ski trajectory line and skiing speed. Skiing line is more or less direct, with maximum speed, which must be under full load on curved skis. In every sport, athletes develop as individuals based on pre-developed and established programs, nor alpine skiing is no exception. Of course, it often happens that the established work program and its effective implementation are separated. In this case, the program must be modified and adapted to new circumstances dictated by the relationship of the program and individual participants. By changing the direction of movement on the ski edges and achieving the same length of turns, skiing speed increases from turn to turn. (Lesnik, Žvan, 2007).

As already mentioned, the small differences can decide the success of each contestant. It is essential to have the necessary knowledge of the tactical elements that need to be in every competition to allow an opportunity to achieve a good result. Tactics is probably the least explored in alpine skiing and approaches should be on to pay more attention. The difference in the perception of coaches and competitors, on the one hand and measure the skiing speed, on the other, often resulting in improper choice of developing ski technique and tactics. All of the above, later becoming a critical factor in the differentiation of good and top racers. Part of the authors believes that more space gives the possibility of development techniques of skiing, if you analyze, in details, previously mentioned facts (Lesnik, Žvan, 2007).

Conclusion

Commenting on the fall line, speed control on the edges of skis depends on the ideal length of the turn and turn lines that skier make. If there fall lines apparent same for two skiers, turn radius will be smaller for skiers who's making the shorter turns. The results would probably be a lot more objective it was possible to measure the entire race in these conditions, and not only its segments. Unfortunately, it is not possible at the moment due to technical and organizational problems. However, these results demonstrate the possibility of at least a better orientation training slalom technique, seeking a better way to select skiing turn lines. Due to the fact that the aim of all the techniques is to achieve the highest speed, the speed achieved by grooming technical skills has little to do with skier's courage. This leads surely at the reason on risk of several falls so the skier's fear was prominent in reducing of skiing speed.

It is important that the competitor learns to recognize when to ski really fast or when it should speed up skiing on a particular part. Therefore, the selection of skiing lines in a particular segment like the subject of this analysis is considered as an important factor that is often crucial when you need to decide who is good and who is the best skier. Developing good ski technique has long been based on experimenting with different positions, useful in ski attitudes and the option of skiing as well as the tactics of competitors. Therefore, to achieve good results in modern, competitive alpine skiing, among the other psychomotor potentials, depending primarily on good technical and tactical parameters. These parameters are based on detailed planning and transformation process management, which denies knowledge base without individual age groups in alpine skiing. In the analysis of the processed segment of skiing parameters is perhaps the most important and equivalent to success. Specifically, it is a special technique and tactical aspects of modern slalom turns, some of which are directly linked to greater or lesser efficiency in the top of the alpine skiing techniques. When solving problems in sport is difficult or even impossible to divide the different aspects, included in the training process is closely related to the tactics used in the competition and skiing these parameters, as well as likely in other sports, is of crucial importance.

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