CAUSALITY OF LAP TIMES WITH TOTAL TIME IN SLALOM

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Summary
The issues which can be best described as the existing rules for skiers' behavior in a race for the World cup in two runs were studied in this article. After the precise data from the run in the race for the world cup in Zagreb had been collected and using the factor and regression models, it was shown that there existed some relationship which was recognized as the importance of the second run in regard to the total result, which also has a bigger predictive value on the total achievement. The reasons for this can be found in calculations related to the final result and in the tactical way of ride. In the practical sense, the results rationalize two runs, especially when the best 30 skiers from the first run participate in the second ride. It is supposed then that the conclusions transparency on to other rides is very high but it is suggested to examine that hypothesis, too.

Key words: *slalom, two races, regression, prediction, tactics*

Introduction
The experience confirmed that the achieved results at particular sections of a track influence more or less the final score. Since the sport result is in the first place for competitors and their coaches, it is very important to know what is going on, what things are related to each other and what are the most important things the final score depends on. According to the FIS competition rules, the competition in Alpine skiing requires a specially prepared track (runway) which elementary must have the appropriate length and altitude balance as well as a number of other characteristics, in order to get it prepared for a regular competition to be held. When the length of a ski track and the altitude balance are considered, the track length in the discipline of slalom for men must be about 500m, with the altitude balance from 180 to 220m according to the rules referring to the races at Olympic Games, World championships and World cup. It is also of a great importance to emphasize that the usual number of door (gates) on a track is from 55 to 75, with the approximate distance between them of 10m. In order to understand this text better it is important to point out that two races are usually held in slalom and that times are summed up and then they are taken as the basis for determining a competitor's position. The achieved time result in one race is somewhat under one minute, which depends on the mentioned and some other parameters, and first of all it depends on the length and difficulty of a track, the number of gates, the track quality conditions and the competitors themselves.

The precise measuring is especially important and it has to be expressed in hundredths of a second. There exist the official and control measurement, where, except total time result, there is the measurement of three or more lap times.

The subject and the problem
The subject is the connection and dependence of the final result in slalom on the achieved results on the first, second and third part of a track as well as the connection and condition dependence of the final result on the results achieved in the first and the second race. The problem of this research is to determine in an exact way which lap times and which race determines the final result better, in other words, the position itself. A particularly special and complex problem is to determine the causes of some consequence after it has been determined.

Aim of work
The primary aim is to learn how much each particular lap time influences final result. The secondary aim is to determine correlation between lap times and final time as well as to determine correlation between final times of the first and second race.

Testees' sample
The testees sample is represented by the best Alpine skiing competitors who are the world's experts in slalom, which means that here the skiers who ski in the World cup are involved.

The quality of the skiers in the world cup is well over the quality of the competitors who ski at the Olympic Games or world, European, Balkan and other kinds of championships. In this particular case, it is about the FIS race for the world cup which was held on 17th February 2008 on Sljeme, Zagreb. The number of 69 competitors started the first race. According to the FIS rules, the first-positioned 30 skiers from the first race started again in the second race.

The sample of variables

As it has already been defined in the subject, problem and aim of this research, variables are a part of the composite of total time results from two races. Three lap times from the first and second race, which were independently monitored, and the total time from both of the races and finally the time, in other words, the sum of times from the first and second race were taken into consideration. The track was divided into three different laps, which is easily concluded based on the times achieved per laps. While examining the lap times from this sample, it can be easily concluded that the second lap was the shortest and that the third lap was a little bit longer than the first one.

Hypothesis

- H1: It is expected to have lap times and total time in statistically important correlation.
- H2: A statistically important correlation is expected to be found between the achieved results from the first and second lap.
- H3: A statistically important prediction of lap times on total time is expected.
- H4: A statistically important prediction of final times in the first and second lap on the total time from both of the laps is expected.

Applied statistical methods

In accordance with the subject, problem and aims of this research, the following parameters were calculated: basic statistical indicators, matrix of intercorrelation in all combinations, multiple regression analysis, coefficient multiple correlation **R** and coefficient of multiple determination **R2**. The matrix of variances, in other words, the structure of the total explained and unexplained variance, known as the matrix of variance analysis, has been presented in of regression analysis.

The matrix of un-standardized and standardized regression coefficients as well as their statistical importance was presented, too. All the coefficients were statistically checked and had a mistake equal or less than $\boldsymbol{p} \leq .05$.

Other relevant indicators

The data were calculated according to the strictest and the most accurate FIS criterions for measurement and making decisions on results. In this sample, the start position was located at the height of 980m and the finish line on the height of 770m with altitude balance of 210m and the number of gates of 59, with the temperature of -9°C at the start position and -8°C at the finish line. During the second ride, the start temperature was -8°C and the finish line temperature was -6°C. The ski run quality, referee organization, time measurement, medical check and other parts of organization were realized strictly according FIS propositions.

Results and discussion

Based on elementary statistics in the Table 1, it can be seen that better results were obtained in the first run $\mathbf{Prt_1}$ = 56.07 : $\mathbf{Prt_2}$ = 57.01 and that the standard deviation was significantly lower, and thus the reason for that can be found in better homogeneousness of the obtained results. The reason for that can also be found in the fact that only first 30 best positioned skiers from the first run can take part in the second run and continue competition. In sport terms, the first run is considered actually as a battle for all or bust in contrast to the second one where different kinds of calculations are done ranging from wishes only to finish the ride, and then to keep up or improve the result from the first run.

Existence of calculations, specific tactics and outwitting in the second race is reflected in standard deviation average times, coefficients of correlation between the first and second run as well as in the correlation coefficient between the time in total in the first and second run.

For sure, the total result prediction is precisely reflected in multiple regression analysis that is in the standardized regression coefficient.

Table 1.

Statistics	Pt_{11}	Pt_{12}	Pt_{13}	Prt_1	Pt_{21}	Pt_{22}	Pt_{23}	Prt_2	Prt_1t_2
Arit.mean.	20.85	13.97	21.25	56.07	20.39	13.50	23.11	57.01	1,53.06
Stand.dev.	0.15	0.14	0.35	0.41	0.18	0.16	1.21	1.27	1.39
Min	22.48	13.68	20.50	55.28	20.09	13.18	22.20	55.90	1,51.36
Max	21.16	14.29	21.87	56.66	20.83	13.85	27.69	61.59	1,58.47

Table 2. shows correlation coefficients between total time based on both of the runs and lap times. The results in Table 2., that is the intercorrelation coefficient undoubtedly show that competitors ski with various kinds of tempo in the second third of track and it could be well said that a certain number of skiers-competitors slow down, some of them keep up the previous tempo and some increase it.

So the conclusion is that no statistical connection between the final total time result and the time result obtained in the second third of track was found. We can understand this kind of results and they are influenced by errors that are inevitable during an Alpine skiing competition. The obtained time results in the third part of track is in the biggest correlation with total time, and the explanation is that the competitors who skied well this part of track had a good result at the end and that those who skied in an ordinary manner were in the last position and those who skied below average manner in the third part of track had below average position. The correlation coefficient among the obtained time results in the third part of track with the final, total time amounts .969, which can be placed in extremely high and statistically important correlation. Based on the obtained values, it can be concluded that the correlation with the final time is found in the highest degree with run speed and quality in the third and first part of track. But from the mentioned data it cannot be partially and literally concluded that the run ride in the second part of the track is not important, but on the contrary, it is important and even more important than the one in the first and the second part but the correlation is low and statistically unimportant due to the simple reason that the run is solved in this part of the track and that's the reason why competitors do calculations: some of them speed up whereas some slow down; some of them try to correct errors they made and some of them are successful whereas some make some additional errors but there exist those who ski with the same tempo from start to finish. It can be said in conclusion that skiing in the second part of track is practically unpredictable and it is not in correlation with final result, but it is surely very important for final result. The correlation matrix structure is similar if the first and second runs are monitored separately.

Table 2.

	Pt_1	Pt_2	Pt_3	Total t_1t_2
Pt_1	1.00	.119	.426*	.576**
Pt_2		1.00	.027	.199
Pt_3			1.00	.969**
Total t_1t_2				1.000

It is very interesting to analyze correlation matrix between the obtained results in time in the first and second run and the time in total, Table 3. It appears absurd, at first glance, to find no correlation between the first and second run whereas it exists between the total time and the first run and it is statistically significant amounting. 42. As it can be seen, the correlation between the second run and total time is extremely high and amounts fully .955. The people who are professionally active in this sport know what the subject is. According to FIS propositions in the world cup, the first run is eliminative, which means that the second run is performed only by 30 best positioned competitors in the first run.

In sport jargon it can be said that runs are performed in maximal degree fighting for all or bust in order to win participation in the second run. The second run is a specific and special story because we have appearance of very specific, surely individual calculations, tactics and decisions of the way of skiing and it is planned what should be done in the second run. Previously agreed kind of tactics is often changed just before the start; for example it is discussed what kind of run to perform if some of the favored skiers drop out the second run or if some spectacular unexpected time result is realized by some outsider. The truth is that a group of competitors is satisfied with their position among 30 and they have no intention to speed up or fight for a little bit better position.

Something similar happens with the rest of competitors with the exception of the favored ones who are not satisfied with their first run results and the ones who are too satisfied with their first run results and therefore they ski a little bit slower but safer, too. It often happens that the skiers who ''run speedily' after the first run time make mistakes, which is reflected later in their final result but at the same time there are those who don't make any mistakes in that forced and aggressive run, in other words they get better results. Both of the types can be found relatively rarely but the truth is that they exist and it is called a surprise in sport terminology, which is very attractive both to audience and the competitors themselves. Nonexistence of total dependence between the second run results and the results from both of the runs, that is, final results, is reflected in correlation coefficient which is really very high and in this sample and it is amounted .955. Correlation coefficients, their degree and statistical importance are shown in the Table 3.

Table 3.

	T_1	T_2	Tkon
T_1	1.00	.135	.423*
T_2		1.00	.955**
Tkon			1.00

One of the aims of this project is to determine the predictive values of lap times with regard to the final time in Tables 4, 5, 6.and 7. On the basis of correlation matrix, it can be predicted that predictive variables, which have a high degree correlation with the criterion one, will have, in regard to the mentioned one, a high prediction. The variances values have been presented in the Tables 4 and 5 where it is recognized easily that the explained variance is almost identical to the total variance and the conclusion is that the point is in the high and total predictor determination on criterion, in other words, the lap times on final time result. The Table 5 presents individual participation in final time result determination.

The standardized regression coefficient **Beta** explicitly shows that the individual prediction is the most relevant in the third part of track and the variable pt3 in the sample of the standardized **Beta** coefficient amounts .891., whereas the other two coefficients are much lower but also statistically important. Based on the other two standardized **Beta** coefficients, a little bit bigger prediction is found in the first track part ride run of variable **pt1** in relation to the second track part ride run of the variable **pt2.**
The Tables 6 and 7 show the regression analysis values where criterion variable was left the same, that is, the total time result from two runs. The predictor variables were expressed in the form of the time result from the first run **sumt1** and the time result from the second run **sumt2**. The total determination is complete and it amounts 1. Individually, both the runs, in other words, the time results obtained are statistically important with much bigger standardized regression coefficient in the second run $\mathbf{Beta_1}$=.30 and $\mathbf{Beta_2}$=.91. The indexes obtained are compatible with the indexes obtained in correlation matrices in the tables 1 and 2.

Table 4. ANOVA. Dependent variable: TKON

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	50.744	3	16.916	13424.151	0.000
Residual	0.029	23	0.001		
Total	50.770	26			

Table 5. REGRESSION. Dependent variable: TKON.

	Unst. Coef.		Stand. Coef.		
Model	B	St.err.	Beta	t	Sig.
Const.	-56.647	1.299		-43.602	0.000
pt1	0.939	0.029	0.178	32.087	0.000
pt2	0.983	0.030	0.167	33.223	0.000
pt3	0.992	0.006	0.891	161.754	0.000

Table 6. ANOVA. Dependent variable: TKON

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	50.773	2	25.386	7.00E+16	0.000
Residual	0.000	24	0.001		
Total	50.773	26			

Table 7. REGRESSION. Dependent variable: TKON.

	Unst. Coef.		Stand. Coef.		
Model	B	St.err.	Beta	t	Sig.
Const.	-60.000	0.000		-1.00E-08	0.000
sumt1	1.000	0.000	0.300	1.00E+08	0.000
sumt2	1.000	0.000	0.914	3.00E+08	0.000

Conclusion

On the basis of the obtained results that are extremely accurate, and from the aspect of collected data and its statistical processing, the following can be safely concluded:

- The first run obtained time results are in positive correlation with the obtained time results in the second run. That correlation is small and statistically unimportant. While comparing correlation and regression coefficient between the total results of both of the runs and the results of individual runs, it is concluded that the second race results are in significantly bigger correlation with the results in the whole run and that they have much bigger predictive value.
- This project can be checked in reality because it proved that exactly due to low and unimportant correlation between the first and second run results; it makes sense to obligatory participate in the second run.
- Regardless of the fact that this project was based on very exact indicators, some wider and stronger generalization could also be considered if the same type of analysis were realized on larger number of FIS runs in the world cup.

Literature

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UZROČNOST PROLAZNOG VREMENA NA UKUPNO VRIJEME U SLALOMU

Sažetak

U istraživanju su proučavani događaji koji se najbolje mogu opisati kao postojeća pravila koja se reflektiraju na ponašanje skijaša u trci za Svjetski kup. Nakon prikupljanja točnih podataka s trke Svjetskog kupa u Zagrebu, te nakon primjene regresijske analize, pokazano je da postoje odnosi koji se mogu prepoznati kao važnost druge utrke u odnosu na ukupni rezultat, koji također ima veću prediktivnu vrijednost na totalno postignuće. Razlozi za ovo mogu se pronaći u kalkulacijama finalnog rezultata i taktičkom načinu vožnje. U praktičnom smislu, rezultati racionaliziraju dvije trke, naročito kad ostane 30 najboljih skijaša iz prve trke sudjeluje u drugoj. Pretpostavljeno je da zaključna transparencija na druge utrke i natjecanje može biti jako velika ali se predlaže istraživanje te hipoteze.

Ključne riječi: *slalom, dvije trke, regresija, predikcija, taktiziranje*

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