THE POSSIBILITY OF PREDICTING THE PERFORMANCE OF ADVANCED SKI ELEMENTS BASED ON THE PERFORMANCE OF BASIC SKI ELEMENTS

Ivana Martinčević[1] and Vjekoslav Cigrovski[2]

[1]*Faculty of Textile Technology, University of Zagreb, Zagreb, Croatia*
[2]*Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia*

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Abstract:

The aim of this research was to predict the success of the performance of advanced ski elements based on the level of performance of basic ski elements, with the ultimate purpose of improving training programmes for alpine ski beginners. The sample of participants consisted of 250 students of the Faculty of Kinesiology University of Zagreb who attended their mandatory classes of the university study subject of Skiing in the academic year 2021/22. The sample of variables consisted of the grades the students earned for their performance of four exam elements, two basic ski elements and the other two belonging to the advanced ski elements group. The basic ski elements were uphill turn (UT), for which the mean of two grades was taken for further analysis due to its performance to both sides – left and right, and snowplough turn (SPT). Advanced ski elements were parallel turn (PT) and short turn (ST). Besides descriptive statistics for each variable, two ordinal logistic regression models were constructed for determining the relationship between the performance of short turn based on the level of performance of snowplough turn, on the one hand, and on the other, between the performance of parallel turn based on the performance of uphill turn. The results of the first ordinal logistic regression analysis (short turn performance based on snowplough performance) showed the existence of a statistically significant linear association of the two ski elements performance ($b=2.15$, $SE=0.72$, $p=.03$). Similar results were obtained in the second ordinal logistic regression analysis for the other pair of ski elements (parallel turn performance based on uphill turn performance): $b=2.36$, $SE=0.24$, $p<.001$. Well acquired dynamic motor stereotypes, reflected in good performance of basic ski elements, are the basis for good performance of advanced ski elements, therefore skipping any step in the teaching process based on progression could have a negative impact on achieving the desired goals.

Key words: *ski skills, training methodology, ski elements, ski learning*

Introduction

The teaching of alpine skiing is at the same time simple as well as a complex process the success of which depends on several factors. On one hand, there is a ski beginner, with the disposition of his/her motor abilities, and his/her expectations regarding the level of ski knowledge he/she wants to achieve. On the other side is the ski instructor who must adjust his/her instruction programme to the set requirements (Mladenović, Cigrovski, Stanković, Prlenda, & Uljević, 2015). The greater the requirements put up by the ski beginner, the more demanding the teaching process in which the instructor aims to teach his/her trainee basic ski knowledge to the highest level by leading him/her to adopting and mastering the elements through a great number of repetitions and then testing the learned in simpler and more complex situations characterised by ever greater dynamics (Scheiber, Seifert, & Müller, 2011). The instructor’s experience in teaching, more precisely his/her knowledge of methodological procedures, appears to be an important factor for the success of the entire process. Choosing the exact specific exercises for the group or the individual at the right moment is what makes a teacher a good methodologist and therefore good at his/her job. According to Aćimović, Joksimović, Petković, and Stanković (2010) and Burtscher, Federolf, Nachbauer, and Kopp (2019), skiing is suitable as a recreational activity for people of almost all ages within their capabilities and ski knowledge provided the proper dosage of intensity and workload is being applied. Nowadays, there are more than 80 million people engaging in skiing and snowboarding, making them one of the most widespread leisure-time activities (Thiel, et al. 2009).

Skiers, skiing down the slopes, use the synergy of their motor abilities and acquired ski knowledge, or skill, to steer the skis. There are several ski techniques, but ski beginners will encounter two basic techniques in their training—the snowplough and the parallel technique (Cigrovski, Matković, B., & Matković, B.R., 2010). Also, they will be taught by means of three ski learning programmes: basic, advanced, and competitive. The programme names are generally accepted in the world, and they imply progressive mastering of the ski elements according to their complexity—from the simplest to more complex ones. The simpler elements are performed on easier slopes at a low speed. Beginners then gradually transit to the acquisition of more complex elements on steeper slopes with respective increases in the movement speed (Matković, Ferenčak, & Žvan, 2004). Progressivity of the basic three elements of the Slovenian national alpine ski teaching programme was tested in research by Lešnik, Žvan, Leskošek, and Supej (2013). The elements (wedge curves, turns with a wedge push off and basic swinging) showed to be placed correctly in terms of progressivity in time durations of individual turns and their phases.

There are three different approaches to learning alpine skiing—the conventional, combined, and direct one (Lešnik & Žvan, 2010). The conventional approach, also known as traditional, uses a great number of exercises for acquiring skiing skills accompanied by a large number of corrective exercises. The mentioned approach is intended for ski beginners and recreational skiers of all levels of motor abilities and prior ski knowledge. It also represents the longest-lasting way of teaching, and it implies the use of both the snowplough and parallel ski technique in exactly specified training phases. Next, the combined approach uses fewer exercises for acquiring skiing skills than the previous one, which makes it a faster way of teaching. This approach is intended for ski beginners with more developed motor abilities, and it uses the combination of the snowplough and parallel technique regardless of the teaching phase. Finally, the direct approach uses the least number of exercises and therefore represents the fastest way of teaching. It is intended for beginners with high motor potential and implies avoidance of the snowplough technique; it only uses the parallel technique. The most widespread approach in the alpine ski training process is the conventional, or traditional, one. Moreover, research performed with college students by Božić, Cigrovski, Očić, Bon, and Škovran (2019) showed that the performance of ski elements correlates with the overall travelled distance on skis, i.e., the greater distance travelled results in a greater number of ski turns, which enables the better acquisition of ski knowledge.

In addition, motor abilities as well as psychological characteristics of a skier influence the learning process and final success and should therefore be considered and improved during preparation for alpine skiing (Božić, Cigrovski, Bošnjak, Jakovljević, & Tešanović, 2017; Cigrovski, Božić, & Prlenda, 2012; Cigrovski, Matković, & Ivanec, 2008; Cigrovski, Matković, B., & Matković, B.R., 2008; Cigrovski, Radman, Konter, Očić, & Ruzic, 2018; Čillík & Razusova, 2014; Joksimović, D., Joksimović, A., & Stanković, 2010).

Research papers on teaching methodology of alpine skiing, i.e., on ways how to improve the alpine skiing learning process for ski beginners, are scarce. Therefore, the aim of this research was to gain insight into the possibility of predicting the level of performance of advanced ski elements based on the level of performance of basic ski elements, with the ultimate purpose of improving training programmes for ski beginners. The hypothesis was that a good level of basic ski elements performance, expressed as high grades ski experts awarded to students' performances, would manifest in a good performance level of advanced ski elements. If the hypothesis is going to be confirmed, it would help to expand methodological approaches to the teaching of alpine skiing by emphasizing the significance of a good basic ski elements skill/performance for the acquisition of advanced ski elements. This would imply that, in the practice of ski teaching, basic ski elements should not be superficially introduced just to move forward in teaching, but rather practiced in different situational conditions to the highest level of proficiency. In later stages of the ski teaching/learning process, they should also be continuously used as a teaching tool not just for mastering the advanced ski elements, but also for corrections in their performance.

Methods

Sample of participants

The sample of participants consisted of 250 students (22.8±1.14 years) of the Faculty of Kinesiology University of Zagreb who attended their regular classes of the university study subject of Skiing in the academic year 2021/22. Among the participants, 110 had some previous knowledge of skiing, and the rest were genuine beginners. They were all taught by the same ski programme. At the Faculty of Kinesiology University of Zagreb, Skiing is a mandatory course in the third year of the undergraduate university study, which is delivered as a conventional teaching programme lasting 10 days. In that period students are introduced to snowplough and parallel ski techniques, and through them they master the basic and advanced ski programme.

Sample of variables

The sample of variables consisted of the grades the students earned for their performance of four ski elements constituting the exam. Two ski elements belong to the alpine skiing basic skills, and the other two were from the advanced level. The basic ski elements were uphill turn (UT), for which the mean of the two grades was taken for data analysis due to its performance to both the left and right side; and snowplough turn (SPT). The advanced ski elements were parallel turn (PT) and short turn (ST). The students' performances were evaluated on a seven-point scale (2, 2.5, 3, 3.5, 4, 4.5, 5), where 2 meant satisfying and 5 excellent performance. Six judges were the university subject teachers and their expert associates with many years of experience in the field. All the students demonstrated their ski skills on the same slope. Each ski element was executed on a suitable terrain configuration. The judges were grading each student's performance while standing below him/her so they could see his/her execution up front, from the side and then from behind as he/she passed them by.

Statistical analysis

For each variable, the basic parameters of descriptive statistics were calculated (arithmetic mean, standard deviation, minimum and maximum value). Since the dependent variables (short turn and parallel turn) were expressed on an ordinal level and the independent variables (snowplough and uphill turn) were either continuous or ordinal, the assumptions of running an ordinal logistic regression were met. As there was only one independent variable included in every model, the assumption of no multicollinearity was not tested. Further data processing was done by two ordinal logistic regression models: one was used for determining the relationship of performance of the short turn based on the level of snowplough turn grade and the other for determining the performance of the parallel turn based on the uphill turn grade. The assumption of proportional odds was tested by the BRANT (Schlegel & Steenbergen, 2020) package. Even though the assumption of proportional odds did not hold (p=.01), it was argued that relaxing this assumption by fitting a multinomial logistic model or a partial proportional odds model is not always needed (Harrell, 2022a, 2022b, 2022c). The results of proportional odds models are meaningful even when the assumption of proportional odds is violated (Harrell, 2022a, 2022b, 2022c). Therefore, ordinal logistic regression models were kept and their results were interpreted through odds ratios (OR) and their corresponding 95% confidence intervals (CI).

Statistical analysis was carried out in RStudio ordinal logistic regression models constructed using the MASS (Venables & Ripley, 2002) package, and the ggplot2 (Wickham, 2016) package was used for visualizing the results. The alpha level of the statistical tests was set at .05.

Results

The results of basic descriptive statistics for the grades the students earned for their performances of four ski elements are shown in Table 1.

A stacked bar plot and a boxplot were constructed to visualize patterns of grades earned by the students for their performance of the advanced alpine ski elements based on the grades received for their performance of basic alpine ski elements (Figures 1 and 2).

The results of the ordinal logistic regression analysis for determining the relationship between the short turn performance based on the snowplough performance are shown in Table 2.

The results show that better performance of short turn depends linearly on the success in snowplough turn execution (p=.03), but no significant quadratic (p=.49) or cubic (p=.56) effects are present.

The results of the second ordinal logistic regression analysis for determining the relationship between the parallel turn performance based on the uphill turn performance to both sides (in the analysis the arithmetic mean of the left and right uphill turn was used) are shown in Table 3.

The ordinal logistic regression model results also show a statistically significant association (B=2.36, SE=0.24, p<.001).

Table 4 was constructed to present ORs and their corresponding 95% CI from both ordinal logistic regression models.

Based on the linear association between the success in the execution of snowplough and short

Table 1. Descriptive statistics of grades the students earned for their performance of ski elements

Variable	N	Mean±SD	Min	Max
UT	250	4.10±0.67	2	5
SPT	250	4.23±0.78	2	5
PT	250	3.83±0.79	2	5
ST	250	3.90±0.94	2	5

Note. N: number of participants; SD: standard deviation; Min: minimum value; Max: maximum value; UT: uphill turn; SPT: snowplough turn; PT: parallel turn; ST: short turn.

Table 2. The ordinal logistic regression results of the relationship between snowplough and short turn

	B	SE	t-value	p-value
Linear SPT	2.15	0.72	2.97	.003*
Quadratic SPT	0.49	0.68	0.72	.47
Cubic SPT	0.34	0.58	0.58	.56

Note. B: beta coefficient; SE: standard error; *significant at p<.05; SPT: snowplough turn.

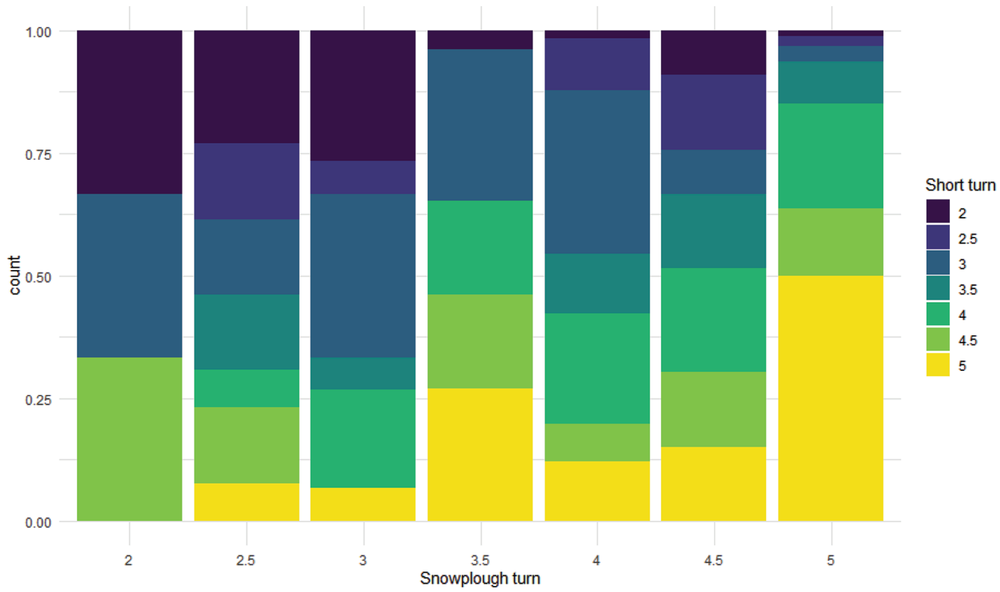

Figure 1. A pattern of grades the students earned for their performance of short turn based on the snowplough turn grades.

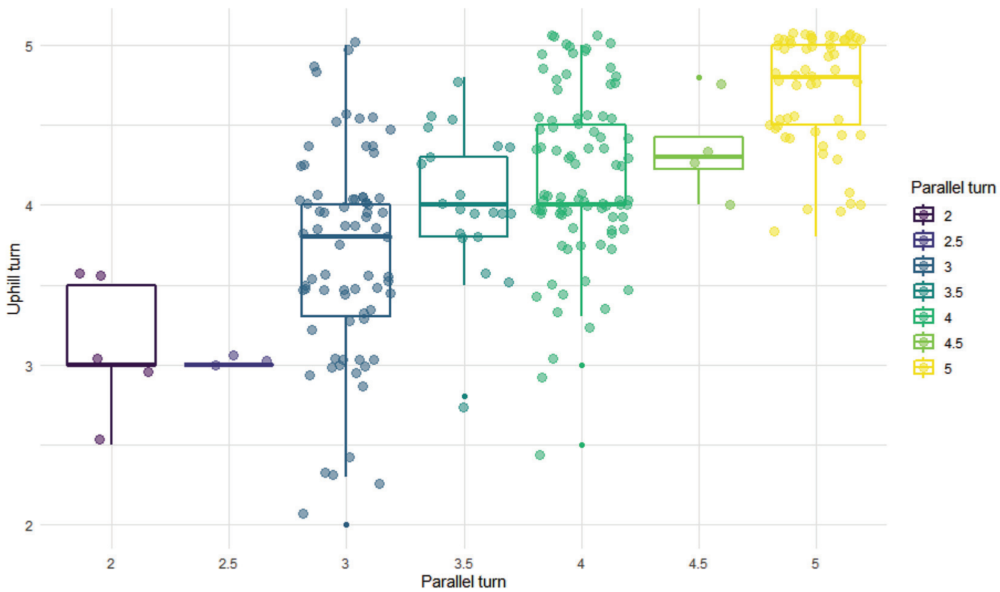

Figure 2. A pattern of grades the students earned for their performance of parallel turn based on the uphill turn grades.

Table 3. The ordinal logistic regression results of the relationship between uphill and parallel turn

	B	SE	t-value	p-value
UT	2.37	0.24	9.77	.000

Note. B: beta coefficient; SE: standard error; *significant at p<.05; UT: uphill turn.

Table 4. Odds ratios and their corresponding 95% confidence intervals from both ordinal logistic regression models

	OR	Lower 95% CI	Upper 95% CI
Linear SPT	8.57	2.10	37.44
UT	10.67	6.73	17.43

Note. OR: odds ratio; CI: confidence interval; *significant at p<.05; SPT: snowplough turn; UT: uphill turn.

turn, for the students who were more successful in snowplough turn, the odds of being more successful in performing short turn were 8.57 times that of the students who were less successful in performing snowplough turn.

Furthermore, for every unit increase in students' uphill turn evaluation, the odds of being successful in the parallel turn were multiplied 10.67 times.

Discussion and conclusions

The main findings on both pairs of ski elements confirmed our hypothesis that ski beginners with a good level of knowledge of basic ski elements would perform better in advanced ski elements. Skiing is a biomechanically determined activity in which more complex elements are built on simpler ones by the movement structure (Cigrovski, et al., 2010). The final manifestation is different, but at the same time, the ski steering mechanisms are completely identical. It follows that the biomechanical structure of ski steering in a snowplough and short turn is the same, which seems somewhat surprising at first glance (Matković & Ferenčak, 1996; Matković, et al., 2004). All movements existing in simple ski elements are also present in more complex ones, with a difference in their performance during a longer or shorter time interval. Therefore, in more complex ski elements, a skier will do all those movements in a much shorter time interval, which makes them biomechanically more complex and more demanding (Matković, et al., 2004; Kim, J.H. & Kim, J.N., 2017). The research aiming at determining the kinetic and kinematic differences between short and parallel turns confirmed a higher complexity of the short turn by analysing certain kinetic and kinematic parameters (Bon, Očić, Cigrovski, Rupčić, & Knjaz, 2021). The short turn is normally taught at the very end of an alpine ski training, after the parallel turn, and the mentioned research justifies that common practice in terms of the progression principle. The parallel turn is mostly used by recreational skiers to ski downhill because it offers an intermediate skier both a sense of security and pleasure (Cigrovski, et al., 2010). It is also used on intermediately steep slopes and in a wider corridor, which enables the skier to do all the necessary movements in a shorter time interval. The short turn is used on much steeper slopes; it is the most dynamic element of the alpine ski learning programme and, therefore, demands the skier to do the same movements much faster (Cigrovski, Rupčić, Bon, Očić, & Krističević, 2020). All the mentioned certainly makes the short turn more demanding and challenging in terms of maintaining body balance (Cigrovski, Matković, B., & Prlenda, 2009; Lešnik, Glinšek, & Žvan, 2015; Vaverka, Vodickova, & Elfmark, 2012). Nevertheless, despite the difference in complexity of the ski elements, the ski steering mechanisms, such as the circular knee function, the correct timing of the movements along all axis, and pressure on the outer ski, are still the same in each of them (Matković, et al., 2004). It is exactly because of the stated that statistically significant association could be explained. In other words, a ski beginner who has earned a high grade for his/her performance of a basic ski element, the snowplough in this case, will probably get a high grade for the performance of a more advanced ski element, the short turn in this research. The association of these two elements is perhaps most evident in the outer leg knee function and its circular motions that steer the skis actively into a turn (Matković & Ferenčak, 1996.; Matković, et al., 2004). Without these circular motions in the knee joint, there is no proper turn on the outer ski (Matković, et al., 2004). Surely the movements that lead to a turn are more complex than just the knee movement, but it is certainly the most important one. So, acquiring the proper knee movement at the very beginning of the ski training process is essential for all further ski element learning. The snowplough is precisely the first ski element where a ski beginner will get to know and learn the mentioned movements that he/she will then later use in the performance of all other ski elements, in different time intervals and corridors. Therefore, it could be said that the basis for successful short turn performance is good knowledge and performance of the snowplough turn with an active knee function (Falda-Buscaiot, Hintzy, Rougier, Lacouture, & Coulmy, 2017).

Omitting the learning of the snowplough turn from the ski learning process of ski beginners, with the goal of faster ski knowledge transfer, was the subject of research done with 126 university students (Cigrovski, et al., 2010). One group of students was taught using the parallel technique exclusively, while in the other group the teaching method combined the snowplough and parallel ski techniques. The participants were graded in five ski elements and the results showed statistically significant higher grades in short and parallel turns of the group taught by the combination of the two techniques. In the conclusions of the stated research higher grades of the group taught by the combination of techniques were attributed to a better adoption of basic ski knowledge, which is important in the later stages of ski training. Based on the obtained results, the authors stated that in the ski beginner training process it was more efficient to use both the snowplough and parallel techniques. These conclusions support the observations of our research based on biomechanical similarities and assumed relationship among all ski technique elements. Also, the greater variety of alpine ski movement, i.e., knowing as many ski techniques as possible, enriches the skier in terms of motor skills, which allows him/her to perform more safely and efficiently in all situational conditions. Skiing in different weather conditions, slope conditions, and off-road skiing, certainly requires the aforementioned (Hebert-Losier, Supej, & Holmberg, 2014).

However, research by Nurković, Kovač, and Idrizović (2011) came to different conclusions regarding the technique used for gaining better results in the adoption of ski knowledge. The research was also done with college students who were ski beginners divided into two groups. One group was taught by the "classical" method of alpine ski learning and the other by the "direct" method. The "direct" method implied learning ski elements without introducing the snowplough technique to the participants. The results showed the "direct" approach to be more efficient in the alpine ski learning process.

As for the other pair of the observed ski elements, uphill and parallel turn, similar conclusions can be made. Here, the relationship is even more emphasized since the uphill turn is an integral part of the parallel turn, or its final part, to be more exact. The accuracy of the stated is confirmed by a higher association obtained in the regression analysis results (Beta=0.75) of these two elements in comparison to the previous two. A less manifested association in some elements, as is the case in the previous two, lies in certain specificities of some ski elements, such as skies in the snowplough or parallel position, which can influence the association results. However, it is to be assumed that the relationship will exist among all ski elements, because successful ski steering in any one of them is the product of identical steering mechanisms, respecting already mentioned specificities of each ski element.

Limitations of this research may lie in the fact that the participants were students of kinesiology who were certainly a preselected group of people in terms of their motor abilities. Some, if not most of them, besides having a good level of motor and functional abilities, have also had previous experience in various sports. The fact that the students were not complete beginners could have impacted the results, although experience shows that sometimes it tends to be more challenging to correct automated wrong motor patterns than to teach them from the beginning (Shadmehr, Smith, & Krakauer, 2010). Also, the objectivity of judges when evaluating the students was not tested, although they had years of experience in grading generations of students. All the mentioned factors could have influenced the results so future research on similar topics should include as many in our research disregarded factors as possible to draw conclusions more accurately.

The teaching of alpine skiing, transferring the ski knowledge, as with any other specific motor knowledge, is based on the principle of gradual progression or learning from simpler to more advanced elements. In skiing, the stated means performing simpler elements on less steep ski slopes under slower movement dynamics at first, and then gradually transferring onto steeper slopes with increasing dynamics. The next step in the process includes learning more advanced elements on much steeper slopes followed by their testing in different situational conditions, with ever-increasing movement dynamics. For the ski beginner to reach that high level of ski motor knowledge will require a lot of time, patience, and practice in the utilitarian exercises that should be repeated an adequate number of times to satisfy the work volume, all under permanent control and correction by the teacher. Good knowledge and good performance of basic ski elements are the basis for successful performance of advanced ski elements, while skipping or bypassing any step in the teaching process based on progression could have a negative impact on achieving the desired goals. This research is valuable for ski instructors as it points out the importance of mastering basic ski elements in various situational conditions. Based on our results, it is suggested that all basic ski elements are used throughout all stages of alpine ski training as a form of didactic exercise for learning more advanced ski elements. This should improve the sole process and allow faster and more efficient acquisition of advanced ski technique elements.

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Correspondence to:
Ivana Martinčević, M.Sc.
Faculty of Textile Technology University of Zagreb
Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia
Phone: +38591 507 4113
E-mail: ivana.martincevic@kif.unizg.hr