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Effects of Learning Alpine Skiing Techniques on Postural Stability

Mijo Ćurić[1], Edin Mujanović[2], Amra Nožinović Mujanović[2], Almir Atiković[2], Mario Oršolić[1,3]

[1]Faculty of Kinesiology Osijek, Josip Juraj Strossmayer University of Osijek, Croatia, [2]Faculty of Physical education and Sport, University of Tuzla, Bosnia and Herzegovina, [3]Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek

Abstract

Alpine skiing is a sport and recreational physical activity which requires fine postural control to maintain balance in challenging conditions. Theoretically, balance dominates in alpine skiing, but coordinated action of the whole body of the skiers is equally important. The aim of this research was to determine the effects of experimental short-term program of intensive training of alpine skiing techniques to postural stability (on Biodex Balance System) of students. The sample is divided into an experimental (31 students, age 21.4±1.0 and body height 180.7±6.3 cm) and control group (34 students, age 20.6±0.8 and body height 180.3±6.8 cm). The results of ANCOVA within variables for the evaluation of postural stability show statistically significant effects of the applying experimental program in all applied variables at the level of significance p=.000. From the mean value results (M) it is obvious that the experimental group achieved better results compared to the identical tests applied to the control group. The results of this research show that learning to ski can improve the ability to maintain balance, especially if it is conducted under the expert supervision of a ski instructor, which can have the effect of reducing the risk of injury.

Keywords: *ski training, students, biodex, dynamic balance*

Introduction

Alpine skiing is a sport and recreational physical activity which requires fine postural control to maintain balance in challenging conditions Staniszewski, Zybko and Wiszomirska (2016) according to Noe and Paillard (2005). Balance is a key component in many functional activities of daily living and many recreational activities and and as an information component of movement is the motor ability to keep the body in a stable position at rest or in motion. In movement, it implies the ability to quickly form compensatory (corrective) movements that are necessary to return the body to a balanced position (Mujanović, Nožinović Mujanović, & Šabović, 2012). In skiing, we talk about dynamic balance, because it is about creating balance position during skating (movement) on skis (in all directions; left-right, forward-backward), (Lešnik & Žvan, 2007). In order for the body to remain in balance, the center of the body gravity must be projected onto the surface of the support (Staniszewski, Zybko, & Wiszomirska, 2016). Since the skier moves on skis, with which he is connected by a ski boot and constantly changes the direction of movement, so the projection of the center of body gravity moves and it is necessary to constantly put it in the right position at a certain time.

Theoretically, balance dominates in alpine skiing, but coordinated action of the whole body of the skiers where work of the legs, upper body and hands is equally important (Mujanović, Atiković, & Nožinović Mujanović, 2014)

Due to its construction, the boot (ski boot) imposes certain mechanical restrictions on the degree of freedom of movement of the ankle, which together with the knee joint and hip joint allow body movements in order to maintain postural stability. On the other hand, when a skier wears a boot and skis, the support surface increases, which makes it easier for him to maintain a stable position on skis and reduce the amplitude of body movements (Noé, Amarantini, & Paillard, 2009). Boots also provide an additional tactile stimulus, recognized by the skin receptor in the lower parts of the shins and feet, as well as a mechanical stimulus related to shin support along the entire length of the tibia in contact with the boot tongue (Staniszewski, Zybko, & Wiszomirska, 2016).

Correspondence:

Mijo Ćurić
Josip Juraj Strossmayer University of Osijek, Faculty of Kinesiology Osijek, Cara Hadrijana 10, pp 330, 31000 Osijek, Croatia
Email: micuric@gmail.com

In alpine skiing, the lower limb, together with visual perception, play a fundamental role in the transfer of stimuli from the external environment to the balance control system, and it is necessary for the foot mechanoreceptors in the ski boot to sense the shape of the ground through the rigid sole of the boot and through the skis in order to maintain ski control (Tchórzewski, Bujas, & Jankowicz-Szymańska, 2013).

Cigrovski, Franjko, Rupčić, Baković, and Matković (2017) state that available balance tests differ greatly not just in their commercial availability but also in a safe and easy way of testing and they claim that theirs research posits balance as the major feature that needs to be incorporated in the conditioning training of people who plan to participate in alpine skiing.

The authors (Ćurić et al., 2018) state that learning setup method must always contain precise settings that allow you to perform the tasks correctly. Ćurić (2020) concludes that there is a causal relationship between mastering skiing technique and motor abilities, or that an increase in the level of motor abilities, agility and static leg strength during learning skiing, if sufficiently trained, can affect the success of mastering skiing techniques.

Also, the effectiveness of the ski program has been confirmed (Staniszewski, Zybko & Wiszomirska, 2016; Şimşek, Arslan, Polat & Koca, 2020) on dynamic balance, but in others, it has been inconclusive (Camliguney, 2013; Cigrovski et al., 2017).

Since the results are not consistent, this research is being conducted and the aim of this research was to determine if there are effects of experimental short-term program of intensive training of alpine skiing techniques to postural stability of students, in order to improve the mastery of ski technique through a cause-and-effect relationship.

Methods

Participants

The test sample included 65 male students enrolled in the second and third year of study at the Faculty of physical education and sport University of Tuzla. The sample is divided into an experimental group (31 students, age 21.4±1.0 and body height 180.7±6.3 cm) and control group (34 students, age 20.6±0.8 and body height 180.3±6.8 cm). Students who participated in the study were healthy, without those excused from physical education for health reasons, and they all gave their written consent to participate in testing. The study was carried out according to the principles of the Helsinki Declaration on experimentation on living subjects (WMA, 2017) and the research was approved by the institutional ethics committee (No. 03-3120-9.2.4/18 from 30th May, 2018).

Measurements

For testing proprioceptive abilities, a stabilization platform was used to test the dynamic balance (Biodex Balance system SD, USA). This device consists of a movable platform that allows oscillations of 20º in all directions relative to the ground and 12 possible levels of stabilization. The platform is connected to a computer program (Biodex, v3.01, Biodex, Inc.), which allows an objective and reliable evaluation of postural stability. The reliability and validity (ICC=0.72-0.89) of this test are very high (Schmitz & Arnold, 1998; Hinman, 2000), and as such are considered exceptionally suitable for this study.

Respondents were first tested on a stabilization platform barefoot, in a natural position on two legs slightly bent at the knee joint and arms next to the body. Afterwards they were tested on a stabilization platform in ski boots, in a natural position on two legs slightly bent at the knee joint (compared to the construction of a boot similar to all models used) and arms next to the body. The place where the respondent stands is determined by the height of the subject. In order to maintain a balance position during testing, respondents were able to perform small body and arm movements. The respondents had to look in front of them, try to maintain a balance position with as few oscillations as possible and be as static as possible. The respondents were tested 3 times for 20 seconds at level 2 of stability (static) with 10 seconds of rest between attempts. The results are expressed as: Overall Stability Index (OSI), Anterior-Posterior Balance Index (APSI) and Medial-Lateral Stability Index (MLSI). Testing was performed with open eyes.

For the assessment of postural stability, the tests were balance on two legs – BTL and balance on two legs with ski boots – BSB. Staniszewski, Zybko and Wiszomirska (2016) used the same test on an AccuSway (AMTI, USA) stabilometric platform.

Procedure

The assessment of motor abilities selected for this research was conducted two days before and two days after the end of the experimental program. The experimental program was implemented on a daily basis during the period from 9 am to 4 pm in duration of 33 hours for 6 days (4 hours of training

Table 1. Design of experimental program elaborated on daily basis

Learning day	Design of experimental program
1st	Determining the initial knowledge of alpine skiing and forming homogeneous groups of skiers by the quality of knowledge; Overview of equipment and attachment and removal of skis; Walking with and without ski poles on the platform, turning around the tops and tails, falling and lifting; Climbing the slope, turning on a slope, falling and lifting; Gliding straight down the gentle slope (on flat terrain and over uneven terrain), with different ways of stopping (at the end of a slope, in a plow, by a transient step); The use of ski lifts; Traversing the slope Traversing the slope with sliding and stoping; Gliding wedge (speed control and stopping in the plow); Wedge turns.
2nd	Repeat alpine skiing technique elements from the previous day; Ski curves with wedge turns; Gliding wedge on a steeper slope (speed control and stopping); Wedge turns on a steeper slope; Parallel turn towards the slope (with sliding and carving the skis); Wedge parallel turn.
3rd	Repeat alpine skiing technique elements from the previous days; Advanced wedge turns with pole plant; Wedge parallel turns on a steeper slope; Parallel turns on a gentle slope.
4th	Repeat alpine skiing technique elements from the previous days; Parallel turns on a steeper slope; Basic parallel turns on a gentle slope.
5th	Repeat alpine skiing technique elements from the previous days; Wedge turns; Wedge parallel turns; Basic parallel turns.
6th	Free practice.

with instructors and 2 hours of free practice for 5 days and on the 6th day 3 hours of free practice).

The experimental program is designed for beginners to learn the basic techniques of alpine skiing and is included in the curriculum of skiing lessons at the Faculty of physical education and sport University of Tuzla. The program itself (Table 1) was precisely determined by the predetermined number of repetitions of a particular methodical exercise or the ski technique itself and was formed on the basis of current knowledge in the training of motor activity of alpine skiing. It has been proven that the number of repetition and training of a particular element of ski technique and the way it is presented affects the higher level of the adopted knowledge of alpine skiing (Grouios, Kouthouris & Bagiatis, 1993; Almåsbakk, Whiting & Helgerud, 2004).

During the period of experimental treatment, the control group performed the regular duties prescribed by the curriculum (training of their choice for a practical exam in judo, handball and dances).

Data analysis

To determine the effects of an experimental program on some motor abilities of students a univariate covariance analysis was applied (ANCOVA). ANCOVA is suitable for comparing two groups that are tested before and after the intervention. The results on the pre-intervention test are treated as a control covariate, i.e. the statistical removal of previously existing differences between the groups (Pallant, 2011). As a preliminary analysis (assumption) for ANCOVA, Levene's test was used to evaluate the equality of variances between the compared groups. Statistical significance was set at $p \leq 0.05$. All statistical analyses were performed with the software package for statistical data processing SPSS Inc. (2008).

Results

Preliminary testing tested the assumption of variance homogeneity where no perceived contingency was noted in the applied variables. The statistical significance of Levene's test in all variables is $p > 0.05$, indicating that observed variance, two groups of respondents, are similar in these variables. This means that there are no significant differences between the variants and the zero hypothesis is accepted and we conclude that the condition of homogeneity is met. Therefore, differences in the size of the experimental treatment effect between the groups can be attributed to the differences due to the treatment.

Table 2. Leven's test of equality of variance for both groups of respondents in the variables for assessing motor skills (balance)

Dependent variable	F	df1	df2	p-value
BTLOSI	.87	1	63	.355
BTLAPSI	3.73	1	63	.058
BTLMLSI	.35	1	63	.558
BSBOSI	3.70	1	63	.059
BSBAPSI	3.58	1	63	.063
BSBMLSI	.27	1	63	.615

Legend: F - Fisher's F ratio; p – level of statistical significance; significance BTLOSI- Balance on two legs Overall Stability Index; BTLAPSI- Balance on two legs Anterior-Posterior Balance Index; BTLMLSI- Balance on two legs Medial-Lateral Stability Index; BSBOSI-Balance on two legs with ski boots Overall Stability Index; BSBAPSI- Balance on two legs with ski boots Anterior-Posterior Balance Index; BSBMLSI- Balance on two legs with ski boots Medial-Lateral Stability Index

Table 3. Results of the ANCOVA for both groups of respondents in the variables for the assessment of motor skills (balance)

Dependent		Control group		Experimental group		ANCOVA	
Variable		M	SD	M	SD	F	p
BTLOSI	I	3.30	1.82	2.15	.68	55.50	.000
	F	3.27	1.69	1.52	.45		
BTLAPSI	I	1.85	.77	1.50	.45	47.78	.000
	F	1.94	.80	1.10	.38		
BTLMLSI	I	1.86	1.07	1.29	.45	38.29	.000
	F	1.84	1.03	.89	.29		
BSBOSI	I	4.87	2.15	4.05	1.81	135.48	.000
	F	4.82	1.86	2.32	1.16		
BSBAPSI	I	3.41	1.54	2.97	1.55	133.70	.000
	F	3.48	1.46	1.56	.73		
BSBMLSI	I	2.24	1.10	2.30	1.18	59.56	.000
	F	2.34	1.22	1.28	.63		

Legend: I – initial testing; F – final testing; M–arithmetic mean; SD–standard deviation; F - Fisher's F ratio; p – level of statistical significance BTLOSI- Balance on two legs Overall Stability Index; BTLAPSI- Balance on two legs Anterior-Posterior Balance Index; BTLMLSI- Balance on two legs Medial-Lateral Stability Index; BSBOSI-Balance on two legs with ski boots Overall Stability Index; BSBAPSI- Balance on two legs with ski boots Anterior-Posterior Balance Index; BSBMLSI- Balance on two legs with ski boots Medial-Lateral Stability Index

The results of the univariate analysis of covariance within the variables for balance assessment in Table 3 show statistically significant effects of the applied program of intensive training of alpine skiing technique in all applied variables. The contribution to these effects that is visible in the balance assessment variables is at a statistically significant level of p=0.000. A review of the results of the mean values (M) in these variables shows that the subjects of the experimental group achieved better results compared to the identical tests applied to the control group.

Discussion

A review of the results shows that all subjects, control and experimental group, in the test with ski boots achieved higher coefficients of stability index compared to identical tests performed without ski boots, which is expected because the ability to control the balance of body position is further limited by ski boots that reduces the mobility of the ankle and requires the involvement of other muscles in order to maintain balance. All balance tests assessed the dynamic component of balance. On the other hand, it is also prominent that the results of the experimental group compared to the control group show lower coefficients of stability index (a lower score is better) at a statistically significant level, and it can be stated that the applied program of intensive training of alpine skiing in all applied variables produced statistically significant effects.

A study (Wojtyczek, Pasławska, & Raschner, 2014) similar to our study on physical education and sports students aged 20-22 aimed at evaluating changes in balance in the medio-lateral direction after the mandatory 7-day ski camp compared to gender and skiing experience, shows that there has been an improvement in maintaining balance after the ski camp. The authors state that the improvements in maintaining a balanced position can be explained by using many different exercises during the skiing week, in which lateral movements and back-and-forth movements appear, which are an integral part of the skiing curriculum.

A study by the authors (Camliguney, Ramazanoglu, Atilgan, Yilmaz, & Uzun, 2012) aimed at observing the effects of intensive ski training, in duration of 6 days, as a new set of skills on the dynamic and static balance of male and female athletes of physical education students and sports that have regular and formal sports training, the results show that there were no statistically significant changes in the static balance test after the program, but in the dynamic balance test there was an improvement in the results of both male and female students ski training group in relation to the control group. The authors state that there was an improvement in the results of the ski group subjects compared to the control group and in the test for estimating the dynamic-isometric strength of the legs. As possible causes of such changes, the authors stated that during skiing, balance and movement controls are the focus of skiing for the lower extremities. This is especially expressed when during training on skis the center of gravity approaches the ground, there are frequent dynamic and isometric contractions of the muscles, which leads to an increase in balance and strength of the legs.

In a study aimed at determining the extent to which several days of skiing and the level of technical skills affect the level of postural stability of skiers (Staniszewski, Zybko, & Wiszomirska, 2016) on students of the Faculty of Physical Education and Sports of the University of Warsaw, beginners and advanced skiers during 9-day ski training camp, it was found that subjects who were skiing beginners had statistically significant improvements in results measured during maintaining a balanced position in ski boots after ski camp. They also state that in attempts in which participants stood on one leg, balance improved mostly in beginners. In conclusion, the authors note that nine days of skiing has a positive effect on maintaining postural stability only in conditions that include measurements in ski boots, or in those conditions in which the program was implemented.

Camliguney (2013), in a study on adolescents in aim to determine the effects of 5-day ski training on dynamic balance and vertical jumping, points out that the program had an effect on stability in the medio-lateral direction while negatively affecting stability in the anterio-posterior direction. Despite the small increase in results, there was no statistically significant increase in performing vertical jumps on one and two legs. The author indicates a relatively short period of ski training as a possible reason for the negative and insufficient effect on some of the subjects' abilities.

Cigrovski et al. (2017), in their study tested participants, after 10 days of alpine skiing, with two balance tests. Participants results did not significantly different in one of the balance test, but in the other balance test they found significant differences in the four out of six variables. Also authors Şimşek, Arslan, Polat, and Koca (2020), in their study, examine the effect of 5 days (25 hours) of ski training on balance performance for individuals who have never had ski training before. They received significantly different results which shows that skiing activity can be recommended especially for the development of dynamic balance performance.

It is necessary to note that the mentioned research was carried out on different devices for measuring both static and dynamic balance, which may have an impact on the inconsistency (contradiction, inconsistency) of the results obtained in the research. By comparing our results with the research results mentioned above, we can say that the skiing program, conducted in this research, has a positive effect on movements in both, the frontal and sagittal plain. Different mechanisms of controlling balance in both plains, which are activated during skiing, could be cause of such an outcome.

The strengths of this study is demonstrated through the use of appropriate instrument to measure dynamic balance, and the application of a specific exercise program.

The limitations of this study a relatively small sub-sample size and that the control group participating in other sports that also can affected dynamic balance. Therefore, recommendations for further research could be: a larger sample size, excluding the control group from any programmed activities and perhaps extending the duration of the program.

In conclusion, a professionally guided skiing program, especially for beginner skiers, which lasts a sufficient period of time can lead to changes in motor skills, especially in balance, as shown by this study. Consequently, our research shows that it is necessary to include balance exercises through fitness training, and directly influence the development of those motor abilities that are crucial for mastering of the elements of alpine skiing techniques, and also result in as well as a preventive effect on the possibility of injury.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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References

Almåsbakk, B., Whiting, H. T. A. & Helgerud, J. (2004). *The efficient learner* / on line/. Downloaded May 5, 2007. s: http://www.springerlink.com/content/xtlcgmmn38bwkupf/

Camliguney, A. F., Ramazanoglu, N., Atilgan, O. E., Yilmaz, S. & Uzun, S. (2012). The Effects of Intensive Ski Training on Postural Balance of Athletes. *International Journal of Humanities and Social Science, 2*(2).

Camliguney, A.F. (2013). The effects of short-term ski trainings on dynamic balance performance and vertical jump in adolescents. *Educational Research and Reviews, 8*(10), 568-572.

Cigrovski, V., Franjko, I., Rupčić, T., Baković, M., & Matković, A. (2017). Comparison of Standard and Newer Balance Tests in Recreational Alpine Skiers and Ski Novices. *Montenegrin Journal of Sports Science and Medicine, 6*(1), 49-55.

Curic, M. (2020). Effects of a Programme of Intensive Training of Alpine Skiing Techniques on Some Motor Abilities. *Sport Mont, 18*(3), 79-82. doi: 10.26773/smj.201015

Ćurić, M., Mujanović, E., Nožinović Mujanović, A., Atiković, A., Mehinović, J., & Nurković, N. (2018). Effects of program of intensive training of alpine skiing techniques on some morphological characteristics. *Sport Scientific And Practical Aspects International Scientific Journal of Kinesiology, 15*(2), 5-9.

Şimşek, E., Arslan H., Polat, M., & Koca, F. (2020). The effect of alpine skiing training on balance performance. *African Educational Research Journal, 8*(2), 357-362.

Grouios, G., Kouthouris, H. & Bagiatis, K. (1993). *The effects of physical practice, mental practice, and video - demonstration practice on the* learning *of* skiing *skills* /on line/. Downloaded May13, 2007,http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=SPH3406 12&site=ehost-live

Hinman, M. R. (2000). Factors Affecting Reliability of the Biodex Balance System: A Summary of Four Studies, *Journal of Sport Rehabilitation*, *9*(3), 240-252.

Lešnik, B. & Žvan, M. (2007). *Our skiing - Theory and methodology of alpine skiing.* Ljubljana: University of Ljubljana Faculty of Sports.

Mujanović, E., Nožinović Mujanović, A. & Šaković, A. (2012). *Alpine skiing: methodology, techniques and tactics*. Tuzla: Off-set.

Mujanović, E., Atiković, A., & Nožinović Mujanović, A. (2014). Relation between Acrobatic Elements Knowledge and Alpine Skiing Parallel Turns among Physical Education Students. *Science of Gymnastics Journal, 6*(2), 83-94.

Noé, F., & Paillard, T. (2005). Is postural control affected by expertise in alpine skiing?. *British Journal of Sports Medicine, 39*(11), 835-837. doi: 10.1136/bjsm.2005.018127.

Noé, F., Amarantini, D., & Paillard, T. (2009). How experienced alpine-skiers cope with restrictions of ankle degrees-of-freedom when wearing ski-boots in postural exercises. *Journal of Electromyography and Kinesiology, 19*(2), 341-346.

Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using the SPSS program. 4th Edition.* Berkshire: Allen & Unwin.

Schmitz, R. J., & Arnold, B. L. (1998). Intertester and intratester reliability of a dynamic balance protocol using the Biodex Stability System. *Occupational Health and Industrial Medicine, 1*, 49.

SPSS Inc. (2008). *SPSS Statistics for Windows, Version 17.0.* Chicago: SPSS Inc.

Staniszewski, M., Zybko, P., & Wiszomirska, I. (2016). Influence of a nine-day alpine ski training programme on the postural stability of people with different levels of skills, *Biomedical Human Kinetics, 8*, 24–31

Tchórzewski, D., Bujas, P. & Jankowicz-Szymańska, A. (2013). Body Posture Stability in Ski Boots Under Conditions of Unstable Supporting Surface. *Journal of Human Kinetics, 38*, 33-44. doi: 10.2478/hukin-2013-0043

Wojtyczek, B., Pasławska, M. & Raschner, C. (2014). Changes in the Balance Performance of Polish Recreational Skiers after Seven Days of Alpine Skiing. *Journal of Human Kinetics, 44*, 29-40.

WMA (2017). *World medical association declaration of Helsinki – Ethical principles for medical research involving human subjects* Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/