# RECREATIONAL LEVEL ALPINE SKIING AND BALANCE-A CAUSATIVE RELATIONSHIP?

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***Abstract***

Alpine skiing is a specific winter sport, primarily due to non-standardized movements. To manage the ski turns and learn and improve ski technique, alpine skiers need specific motor abilities. Through this investigation we wanted to show the importance of balance during initial phases of alpine ski learning. On the other hand, we aimed to determine if alpine skiing influenced balance. We included 96 participants, randomly assigned into two equal-sized groups. Both the participants of control and experimental group participated in assessment of balance on balance board with attached Gyko instrument while wearing ski boots. After initial testing, participants of the experimental group participated in the 10-day alpine ski school, while participants of the control group refrained from physical activity. Two days after completion of alpine ski school all participants were once again tested according to the same protocol with the AP_L test. Participants of the two groups had comparable baseline characteristics and did not differ in the initial balance testing. Moreover, there were no significant differences in the final balance test in the control group. On the other hand, participants of the experimental group achieved better results in balance assessment test after completing 10-day alpine ski school program ($p=0.00$). Improvement was especially evident for those participants of the experimental group who had initial poorer results in balance test ($p=0.00$), although improvement was also noticed for participants who were achieving better results during initial balance assessment ($p=0.02$). Our results confirm that balance is important for learning basics of alpine skiing, but moreover that structured alpine ski program leads to improvement of balance in adult alpine ski beginners.

***Key words****: alpine skiing, GYKO, ski school, motor ability, development.*

## Introduction

Balance is a motor ability of maintaining projection of center of body mass beyond the surface of support if possible. Each motor ability can be developed during specific exercises such as conditioning training or sport, which leads to improvement of motor abilities (Steinberg et al., 2016). The prerequisite of well performed alpine ski turn is the ability of a skier to maintain optimal central position on skies during each phase of a turn (Loland, 2009). This is the reason why balance is incorporated in conditioning training as well as skiing trainings of ski competitors from the beginning phases in early childhood (Raschner et al., 2017). Moreover, it is well known that balance, among other, prevents injuries during alpine skiing on competitive level (Hrysomallis, 2011). On the other hand, knowledge on correlation between specific field tests for assessment of balance and process of learning alpine skiing is scarce (Cigrovski et al., 2016). The probable reason is in often unreliable field tests for assessment of balance, which due to investigational protocol and inclusion of recreational level skiers and ski beginners need to be executed on field, by ski slopes (Lešnik et al., 2017). While motor abilities cannot be directly measured but are rather assessed by different tests, it is important to use tests with good metric characteristics which are at the same time adopted to specific challenges of alpine skiing and testing conditions (Ružić et al., 2008). For this specific reason Ružić et al. (2011) investigated relations between laboratory and field tests for assessment of balance and success of performance of elements of ski technique and found higher predictability of field balance tests for success of alpine ski technique. Therefore, it is important that tests for balance assessment besides good metric characteristics are adopted to test conditions and examinees' current abilities. The more developed balance correlates to number of repetitions and number of trainings that alpine skiers gain through conditioning and alpine ski trainings (Steinberg et al., 2016; Raschner et al., 2017). Mentioned research also showed that lack of balance increases the risk of injuries and has detrimental effects on ski technique, which is especially evident during periods of growth and development of young competitive skiers.

Regardless the level of alpine skiers (competitive or recreational) during learning and improvement of alpine ski technique skiers need to achieve specific lateral movements in the core and lateral and circular movements in hips and knees. To do so, skiers need to maintain balance position while moving the projection of body mass forwards, backwards or in lateral directions (Műller &

Schwameder, 2001; Wojtyczek et al., 2014). Malliou et al. (2004) investigated the influence of balance training on success during beginning phases of alpine ski learning by using specific exercises in ski boots. Besides balance development, mentioned exercises help ski beginners adapt to specific ski equipment and learn to move.

On the other hand, there is no research on influence of alpine ski school on development of balance in recreational level skiers. Namely, during learning basics of alpine ski technique, ski beginners must constantly perform lateral movements in combination with forward and backwards movements to achieve and maintain balance position on skies during a ski turn. The assumption is that 10-days alpine ski school will improve balance. The aim of this research is to investigate the changes in the balance in ski beginners before and after structured alpine ski program.

**Methods**

*Participants:* This research included 96 participants (42 females and 54 males; average age 22±3 years). Participants were on average 174.37 cm high and weighed 73.09 kg. All participants were students of Faculty of Kinesiology, and ski beginners. They were not injured, nor did they have any medical issues during the testing period. Aside being involved in this research, they did not participate in any additional physical activity. Before the initial testing they were randomly assigned to two equally sized groups; experimental and control. They were balanced according to gender and anthropometric characteristics. Participants were in detail informed about the purpose of this research and study protocol and gave their consent for the participation. The study was approved by Ethics Committee of Faculty of Kinesiology, University of Zagreb.

Study Procedures: We assessed the balance by using device Gyko. Gyko is produced by manufacturer Microgate and comes with appropriate software Gyko MicrogateRePower 1.1.1.10. Gyko consists of accelerometer, gyroscope and magnometer, and mentioned parts enable Gyko to register any movement of 1 mm in three planes: linear acceleration, angle speed and magnetic field. It can register motion in one of the three planes, i.e. in all three simultaneously. Balance board is constructed so that it enables movements exclusively in the anterio-posterior way. The standing surface of the board is 40x40 cm, and height between ground surface and standing surface is 12 cm (Figure 1.). Gyko was positioned in the central, concave part of the standing surface. Variable used for assessment of balance was overall anterio-posterior path AP_L (cm). Determined variable represents overall (absolute) shift of instrument from starting point either to anterior or posterior direction.

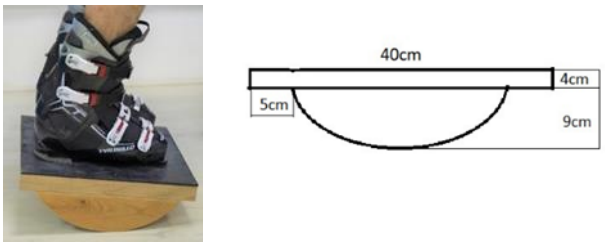


Figure 1. Participant wearing ski boots standing on a balance board in start position for balance testing

Study Protocol: After participants' random assignment to either control or experimental group initial balance assessment was performed. Measurements were done in laboratory conditions, after determining length of participants' left foot. They were then given appropriate ski boots, using which they climbed the balance board. Before the testing, participants could hold on to the laterally positioned stalk, helping them reach the starting position half-squat, with legs being in the hip width. Gyko instrument was placed in the concave part of the balance board between the participants' legs. Participants had to let go of the stalk and try to keep the balance for five seconds. This first try was not measured but rather served participants to accommodate to balance board. Second try and additional two were measured. Participant had to hold on to the stalk until balance board became still and then let go of the stalk upon hearing the sound signal made by Gyko. Participants were asked to remain in the balance position, without the balance board touching the ground for 15 seconds. Each participant had 3 tries to remain balance for 15 seconds and recorded was the first attempt of three in which the 15 second goal was reached. After balance testing, participants of the experimental group were included in 10-days structured alpine ski school. During the alpine ski school all participants had equal conditions concerning hours of learning and practicing basics of alpine skiing during morning (4 hours) and afternoon (2 hours). They had ski equipment of similar quality and learned according to the same program, with identical methodical exercises. Number of repetitions of elements of ski technique as well as each methodical exercise was previously defined and ski instructors received detailed information prior to ski school. Participants were learning the following elements of ski technique: traversing, uphill turn, snow plough turn, basic turn, parallel turn and short turn. For 10 days while participants of experimental group learned alpine skiing, those pertaining to control group constrained of physical activity. Final balance testing was performed two days after participants of the experimental group returned from ski resort, following the same protocol as the initial balance testing, in same laboratory conditions.

Statistical analysis: For the statistical analysis Statistica version 13.3 for Windows was used. Kolmogorov-Smirnov test was used to test the normality of distribution. Basic descriptive parameters were calculated (mean, standard deviation, minimum and maximum). Significance of differences between the experimental and control group was tested by T-test or Wilcox test depending on normality of data distribution. Results were significant if $p<0.05$.

**Results and discussion**

Basic descriptive parameters measured during initial and final balance testing are given in Table 1.

Table 1 Basic descriptive parameters measured on a balance board during initial and final balance testing for participants of experimental and control group

| | N | Mean | Min | Max | SD. |
|---|---|---|---|---|---|
| AP_L_E_IN | 48 | 35.93 | 18.91 | 82.97 | 12.62 |
| AP_L_C_IN | 48 | 32.37 | 12.02 | 57.71 | 10.84 |
| AP_L_E_FI | 48 | 27.68 | 11.71 | 56.89 | 9.70 |
| AP_L_C_FI | 48 | 32.18 | 17.02 | 51.97 | 8.28 |

*Legend: AP_L_E-IN-anterio-posterior length experimental initial; AP_L_C_IN-anterio-posterior length control initial; AP_L_E_FI-anterio-posterior length experimental final; AP_L_C_FI-anterio-posterior length control final.*

Differences between participants of the experimental and control group in the balance test during initial measurement are given in Table 2.

Table 2 Differences between the two groups in the balance test during initial assessment (Wilcox test)

| | N | T | Z | p |
|---|---|---|---|---|
| AP_L_C_IN & AP_L_E_IN | 48.00 | 413.00 | 1.79 | 0.07 |

*Legend: AP_L_C_IN-anterio-posterior length control initial; AP_L_C_FI-anterio-posterior length control initial.*

There were no significant differences between the experimental and control group in the initial balance testing ($p=0.07$).

In Table 3 are results of Wilcox test for dependent samples in control group. The results between initial and final balance testing were non-significant.

Table 3 Wilcox test for participants of control group in AP_L variable

| | N | T | Z | p |
|---|---|---|---|---|
| AP_L_C_IN & AP_L_C_FI | 48 | 587.00 | 0.01 | 0.99 |

*Legend: AP_L_C_IN-anterio-posterior length control initial; AP_L_C_FI-anterio-posterior length control final.*

In Table 4 are presented results of Wilcox test for the participants of experimental group.

Table 4 Wilcox test for the experimental group in AP_L variable

| | N | T | Z | p |
|---|---|---|---|---|
| AP_L_E_IN & AP_L_E_FI | 48.00 | 149.00 | 4.50 | *0.00 |

*Legend: AP_L_E-IN-anterio-posterior length experimental initial; AP_L_E_FI-anterio-posterior length experimental final.*

There was a statistically significant difference between the initial and final balance testing. After completion of 10-day alpine ski school participants' path on a balance board decreased.

In Table 5 are shown results of basic descriptive parameters measured during balance assessment for experimental group when stratified according to their initial achievement in balance testing to lower and higher achievers.

Table 5 Basic descriptive parameters for higher and lower achievers in the experimental group

| | N | Mean | Min | Max | SD |
|---|---|---|---|---|---|
| AP_L_E_IN | 28 | 27.77 | 18.91 | 35.84 | 4.93 |
| AP_L_E_FI | 28 | 23.98 | 11.71 | 46.25 | 6.78 |
| AP_L_E_IN_L | 20 | 47,36 | 36,10 | 82,97 | 11,11 |
| AP_L_E_FI_L | 20 | 32,86 | 13,97 | 56,89 | 10,90 |

Legend: AP_L_E-IN-anterio-posterior length experimental initial; AP_L_E_FI-anterio-posterior length experimental final; AP_L_E-IN_L-anterio-posterior length experimental initial lower achievers; AP_L_E_FI_L-anterio-posterior length experimental final lower achievers.

In Tables 6 and 7 are shown results of the balance assessment for the higher achievers and lower achievers in the initial and final balance testing.

Table 6 Balance assessment of higher achievers in the initial and final testing (T-test)

| | Mean | SD | t | p |
|---|---|---|---|---|
| AP_L_E_IN | 27.77 | 4.93 | 2.60 | *0.02 |
| AP_L_E_FI | 23.98 | 6.78 | | |

Legend: AP_L_E-IN-anterio-posterior length experimental initial; AP_L_E_FI-anterio-posterior length experimental final.

Table 7 Wilcox test results for lower achievers in the balance

| | N | T | Z | p |
|---|---|---|---|---|
| AP_L_E_IN & AP_L_E_FI | 20.0 | 6.00 | 3.70 | *0.00 |

Legend: AP_L_E-IN-anterio-posterior length experimental initial; AP_L_E_FI-anterio-posterior length experimental final.

Both the higher and lower achievers improved in balance assessment during final testing ($p=0.02$ and $p=0.00$, Tables 6 and 7 respectively), although improvement was

greater in the lower achievers (p=0.00, Table 7).

Our research showed the positive influence of alpine ski school on development of balance in recreational level skiers. Experimental group, that between the initial and final balance testing participated in structured program of alpine skiing had better results in final tests for assessment of balance. On the other hand, the difference in results achieved during balance testing was nonsignificant in the control group, suggesting that skiing made the positive effects seen in the experimental group. The essence of alpine ski technique is in controlling the outer and dosing of inner forces which take place during very dynamic conditions while mastering ski terrain. To be successful, skiers must constantly attain optimal balance position on skies. For this reason, the program of alpine ski schools includes learning of lateral body movements, both lateral and circular movement in leg joints together with proper timing of movement of center of gravity forwards and timing of its return to central position (Cigrovski & Matković, 2015). To maintain the optimal balance position or to be able to regain it, one must constantly move body parts and direct inner forces from the center of body mass to the foot and outer ski, where the contact with surface should be placed (LeMaster, 2010). Therefore, since skiers' body mass must be placed mainly on the outer ski, alpine skiing provides the possibility to constantly exercise balance on one leg, which in the end leads to development of this motor ability. Ski boots are an important part of ski equipment that shield the ankle and foot from injuries, help in directing skies and finding optimal balance on skies. On the other hand, due to the material they are made of, they limit the movements in ankle and partly in foot which negatively affects the ability to maintain central balance position during skiing. It is a known fact that ski beginner has the wider position on skies to be able to gain better stability and larger support surface. As ski knowledge increases alpine skiers learn the moves that help them maintain the optimal balance position with narrower ski position. Besides learning specific movement needed to maintain balance position on skies, ski beginner through alpine ski school also develops balance. During first rides, ski beginners must conquer not only the ski slope but also sagital movements forward and backwards to basic ski position to be able to maintain balance on skies (Cigrovski & Matković, 2015). To continuously be in basic ski position regardless of ski terrain and speed and to be able to move center of body mass forwards and move it back again is the theme of initial days and hours of alpine ski school. We hypothesized that mentioned exercises and tasks which are systematically repeated aid in balance development. Presented results are the confirmation that 10-day alpine ski school influences results in chosen test for assessment of balance. Similar assumption was also confirmed in research by Wojtyczek et al. (2014), with results in balance tests during seven-day alpine ski school. Moreover, mentioned investigation showed balance improvement regardless of gender and especially for participants with poorer initial results. While interpreting our results and results of Wojtyczek et al. (2014), one must keep in mind that both included students of Physical education, whose basic results are higher than that of general population of the same age. None the less, this does not diminish the obtained results but rather suggests the need to further expand the research and include the participants with different characteristics. Mentioned, if results would be confirmed, would strengthen the findings with even greater certainty. Similarly, Malliou et al. (2004) determined that practicing balance on balance board while in ski boots improves learning elements of alpine ski technique. Specific exercises performed by participants of alpine ski school helped them to achieve better results compared to group of participants that did not perform the exercises. It is well known that balance is easier to be achieved on an unstable surface with eyes opened than closed (Hrysomallis, 2011). As conditions on ski terrains change due to weather, so does the visibility. Fogg, snowing and wind as well as going from sunny to a cloudy part of ski terrain, can alter the visibility and balance. During mentioned conditions, skiers are more likely to disrupt optimal balance position. This additionally is yet another confirmation of importance of balance for not only learning alpine ski technique but rather to ski safely in different conditions in which alpine ski is learned.

## Conclusion

Obtained results confirm the importance of balance for learning basics of alpine skiing, but moreover add the knowledge that structured alpine ski program leads to improvement of balance in adult alpine ski beginners.

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## MOŽE LI SE SKIJANJEM NA REKREACIJSKOJ RAZINI UTJECATI NA RAZVOJ RAVNOTEŽE?

**Sažetak**

Alpsko skijanje je izrazito specifičan sport na snijegu prvenstveno zbog nestandardnih pokreta tijela. Za lakše upravljanje skijama tijekom izvođenja zavoja te učinkovitije učenje skijaške tehnike skijaškim su početnicima potrebne motoričke sposobnosti. Ovim se istraživanjem pokušalo ukazati na važnost motoričke sposobnosti ravnoteže tijekom učenja osnova alpskoga skijanja, ali isto tako utvrditi utjecaj same škole skijanja na razvoj ravnoteže kod odraslih skijaških početnika. U istraživanju je sudjelovalo 96 ispitanika, nasumično podijeljenih u dvije veličinom jednake grupe. Procjena ravnoteže učinjena je u skijaškim cipelama, na početku i na kraju istraživanja testom u kojem je korišten uređaj Gyko. Ispitanici eksperimentalne grupe su nakon inicijalnog testiranja učili osnove alpskoga skijanja u trajanju od 10 dana, dok ispitanici kontrolne grupe u navedenom periodu nisu bili tjelesno aktivni. Nakon završetka skijaške škole svim ispitanicima ponovno je procijenjena ravnoteža testom AP_L. Na početku ispitivanja nije bilo razlike u karakteristikama ispitanika kontrolne i eksperimentalne skupine niti u njihovim rezultatima u testu za procjenu ravnoteže. Također, nisu utvrđene razlike niti u rezultatima finalne procjene ravnoteže kod ispitanika kontrolne skupine. Ispitanici eksperimentalne skupine su imali bolji rezultat u testu ravnoteže nakon 10-dnevne škole skijanja ($p=0.00$). Posebno se ravnoteža popravila kod ispitanika eksperimentalne skupine koji su imali lošije inicijalne rezultate u testu ravnoteže ($p=0.00$), no statistički značajno poboljšanje ravnoteže škola skijanja polučila je i kod ispitanika s inicijalno boljim rezultatima u testu procjene ravnoteže ($p=0.02$). Ravnoteža je bitna motorička sposobnost za učenje osnova alpskoga skijanja, a samom školom skijanja može se utjecati na razvoj motoričke sposobnosti ravnoteže.

***Ključne riječi:*** *alpsko skijanje, GYKO, škola skijanja, motoričke sposobnosti, razvoj.*

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