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EFFECTS OF SKIING TRAINING ON SELECTED PARAMETERS OF POSTURAL BALANCE AMONG STUDENTS OF THE OPOLE UNIVERSITY OF TECHNOLOGY

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Abstract

It is difficult to overestimate the role of balance in the life of human beings. Postural stability plays a fundamental role in life and its deficiencies can lead to considerable difficulties in performing everyday activities. Activity is understood as a form of recreation that can promote the development of behaviour in which balance is improved so as to make everyday life easier.

The main objective of the study reported in this paper is to discuss the differences occurring during the system of balance that is maintained by subjects as a result of practicing downhill skiing and snowboarding. The study involved students of Physical Education (42 subjects, aged: 21.15±1.47) who were subjected to an experimental study concerned with the analysis of postural balance prior to and following a winter sports training program.

Throughout the study, a Kistler Force Plate was applied during experiments with subjects performing tasks with eyes open and closed and the participants either wearing ski boots or performing project trials barefoot. Subsequently, the subjects completed the Wingate anaerobic test and the entire course of the test was repeated. The following stage of the experiment involved the same test program that was repeated after completion of a 5-day ski training program by the students, whose initial phases involved the test developed by Haczkiewicz (3).

The analysis of the study's results demonstrates a degree of adaptation in the subjects with regard to postural balance that included a decrease in the regression of the results after completing the Wingate test for trials performed following the training program. This result offers a foundation for the recommendation of downhill skiing practice and snowboarding as ways of assisting postural balance control during preparation for exercise in conditions when maximum and supra-maximum effort is exerted.

Key words: *health, skiing, recreation*

Introduction

Everyday life poses considerable challenges to human movement and one key aspect that does not attract sufficient attention is associated with maintaining postural balance. Balance forms an indispensable element of all activities in which humans engage. However, it starts to attract our interest only at the time when a deficiency of balance occurs and when tasks which previously posed no problems become surprisingly complex. In such a case, deficiency of balance related to an injury or illness focuses our attention quite unexpectedly. The complex structure and multitude of organs participating in the process of balance maintenance by the human body makes the process concerned with identifying its particular elements a much impeded task. In particular, this task is difficult in terms of the conditions of experiments performed in variable external conditions or when we are faced with the need to perform a conscious control of balance following its loss.

Downhill skiing and snowboarding form some of the disciplines which offer considerable requirements in terms of postural balance control. In this context, balance is understood as the degree of precision control of the location of the body's center of mass and the height of the center of the body's gravity, when mass is

dynamically applied and relieved (2). The effect of practicing these forms of recreation on the motor skills of the individuals who practice them and the impact of these skills on the ability to learn new movement patterns seems to be beyond any doubt. The controversy emerges when real tests are performed concerned with the changes in the motor skills of skiers who are subjected to a variety of forms of training. On the basis of earlier reports focusing on this subject[1] , such an effect has been observed – the level of balance control has improved in all subjects and no significant differences between genders have been observed.

Objective of study and research questions

The principal objective of this work is concerned with verifying the impact of practicing downhill skiing and snowboarding on the level of balance control and assessment of applicability of these sports in the improvement of movement ability. The objective of researching the effects of activity on balance control and the correlation between postural balance and ability to quickly acquire skiing skills applied the following questions:

1. What balance-related parameters are related to the practice of downhill skiing and snowboarding?
2. Are there any significant changes in the balance control process of individuals subjected to a short-term downhill skiing and snowboarding training program?
3. Does anaerobic effort affect the change of balance control and what is the effect of the course of the skiing and snowboarding training program on it?
4. Which of the selected parameters can be applied to differentiate between the effects of skiing and snowboarding effort on postural balance?

Materials

The testing projected in this study was performed in July 2017 at the site of the Faculty of Physical Education and Physiotherapy, Opole University of Technology, Opole, Poland. The experiment included 42 men, students of Physical Education at Opole University of Technology (age: 21.15±1.47 years).

Methods

The individuals who participated in the experiment were subjected to testing using Kistler Force Plate. The study was performed four times: with the subjects' eyes open and closed and subsequently the tests were repeated with the subjects wearing ski boots. The test weight used for the Wingate test was 7.5% of the participant's body mass and the test duration was equal to 30s. Subsequently, the entire test program was repeated.

The following stage of the experiment involved a five-day downhill skiing and snowboarding training program conducted in the mountains. The subjects were assigned to homogenous groups with regard to their skiing skills. The tool applied for the classification was based on the Haczkiewicz test (3).

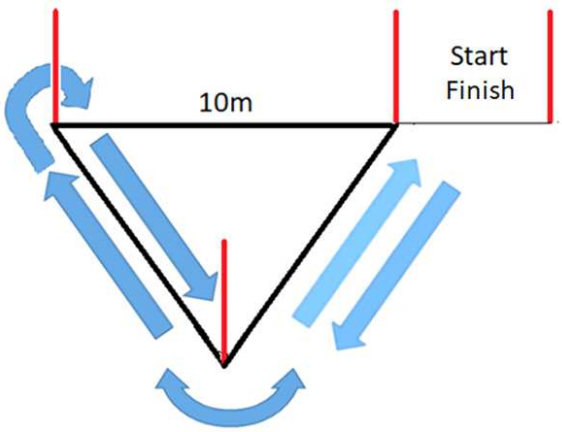

Fig. 1. Diagram of Haczkiewicz test

The test was performed on a hill with an inclination of 15 degrees. The test applied a route around an isosceles triangular shape with a base at the top of the route. The length of the sides of the triangle was 10 meters. The duration of the trials was measured with the accuracy of 0.01s. Throughout the training, the students acquired basic skiing and snowboarding skills, in

[1] Jaskólska A. 2002. Motor control by the nervous system (in Polish). [In:] Jaskólski A. (Ed.) Podstawy fizjologii wysiłku fizycznego AWF Wrocław.

particular focusing on the details of technique. The training program included:

1. Familiarization with skiing and snowboarding equipment and conditions on the piste,
2. Walking echnique on flat areas, ascending, descending, standing up and falling down,
3. Skiing stance, travelling in a straight line and traversing a piste, braking and speed control (snowplough, sideslip and lateral slip),
4. Changes of direction (snowplough, turning and edging maneuvers),
5. Methodology of side slipping with parallel skis, skidding and turning in steps,
6. Metholodogy of teaching foot maneuvers.

Statistical methods

On the day of their return to the University following the completion of winter training, the students were subjected to a cycle of testing that was identical to that completed before the skiing training. This stage involved the analysis of two parameters:

1. Standard deviation of the time series representing foot center of pressure expressed in mm;
2. Mean velocity of the time series representing foot center of pressure expressed in mm/s.

The significance level of the differences was assessed by the ANOVA test for dependent variables, with the significance level of $p < 0.05$.

In addition, the assessment was performed by using the Pearson's Correlation Coefficient for Haczkiewicz Test and for trials applying the Kistler force plate.

Results

The first of the analyzed parameters was the mean velocity of the time series representing foot center of pressure and these results demonstrate an inconsiderable deterioration with regard to the control of the body's center of mass; however, these results do not demonstrate statistical significance (Table 1).

Table 1. Standard deviation of the time series of the middle point of foot pressure for tests performed prior to and following the training classified according to the plane [mm/s]

Standard deviation of the time series [mm]				p
Test	Plane	Prior to skiing training	Following skiing training	
Eyes open; wearing boots	ml	2.35 ± 0.87	3.63 ± 3.25	0.99971
	ap	5.04 ± 1.8	6.51 ± 3.67	1.00000
Eyes open; barefoot	ml	2.8 ± 1.08	3.58 ± 1.47	0.976668
	ap	4.43 ± 2.37	5.2 ± 2.28	0.994782
Eyes closed; wearing boots	ml	2.42 ± 0.96	2.61 ± 1.16	1.000000
	ap	5.31 ± 2.17	5.71 ± 1.94	0.999888
Eyes closed; barefoot	ml	3.59 ± 1.45	4.38 ± 1.82	1.000000
	ap	5.71 ± 1.68	6.42 ± 2.08	0.999277
Wingate eyes open; wearing boots	ml	2.59 ± 1.11	3 ± 2.52	1.000000
	ap	4.78 ± 1.87	5.61 ± 2.38	1.000000
Wingate eyes open; barefoot	ml	3.31 ± 1.54	3.5 ± 1.09	0.747804
	ap	4.84 ± 1.78	5.84 ± 2.65	1.000000
Wingate eyes closed; wearing boots	ml	2.88 ± 1.17	3.52 ± 2.78	0.999916
	ap	6.57 ± 2.15	6.6 ± 3.51	0.739929
Wingate eyes closed barefoot;	ml	4.18 ± 1.93	4.32 ± 1.51	1.000000
	ap	6.22 ± 2.81	6.79 ± 2.13	1.000000

Statistically significant differences are marked by use of Italics

Table 2. Mean velocity of the time series of the middle of foot pressure for tests conducted prior to and following ski training according to the plane [mm]

Mean velocity of the time series of the middle of foot pressure [mm/s]				P
Test	Plane	Prior to skiing training	Following skiing training	
Eyes open; wearing boots	Ml	8.36 ± 3.03	10.66 ± 6.88	*0.000169*
	Ap	15.12 ± 6.34	17.31 ± 5.94	1.000000
Eyes open; barefoot	Ml	7.61 ± 2.45	8.97 ± 2.45	0.696361
	Ap	9.73 ± 2.34	13.61 ± 5.37	*0.001918*
Eyes closed; wearing boots	Ml	9.05 ± 3.01	9.28 ± 3.28	*1.00000*
	Ap	17.11 ± 5.23	18.76 ± 5.18	1.00000
Eyes closed; barefoot	Ml	9.79 ± 3.56	10.97 ± 3.33	*0.000169*
	Ap	14.25 ± 3.8	16.93 ± 5.24	1.00000
Wingate eyes open; wearing boots	Ml	9.01 ± 2.57	9.3 ± 4.55	1.00000
	Ap	17.57 ± 4.17	17.76 ± 5.26	0.999997
Wingate eyes open; barefoot	Ml	8.64 ± 2.42	9.07 ± 2.61	1.00000
	Ap	14.39 ± 3.96	15.13 ± 5.29	1.00000
Wingate eyes closed; wearing boots	Ml	10.26 ± 3.66	10.83 ± 4.32	1.00000
	Ap	20.87 ± 6.63	21.12 ± 5.33	0.996335
Wingate eyes closed; barefoot	Ml	11.03 ± 3.54	11.14 ± 3.33	0.995061
	Ap	17.1 ± 4.43	18.16 ± 4.97	0.999991

Statistically significant differences are marked by use of Italics

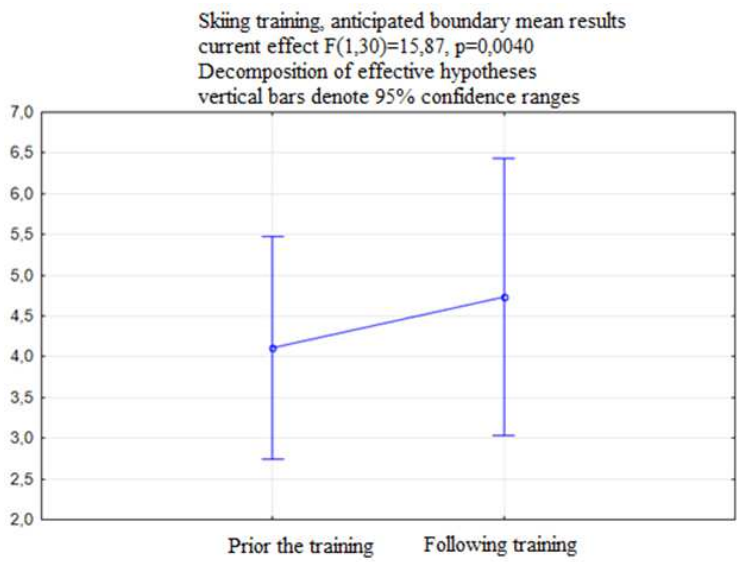

Fig. 2. Changes in standard deviation of the time series representing foot center of pressure prior to and following ski training [mm]

The trials conducted following the completion of the ski training demonstrate an increase in terms of the investigated parameter as a result of the completion of the training program.

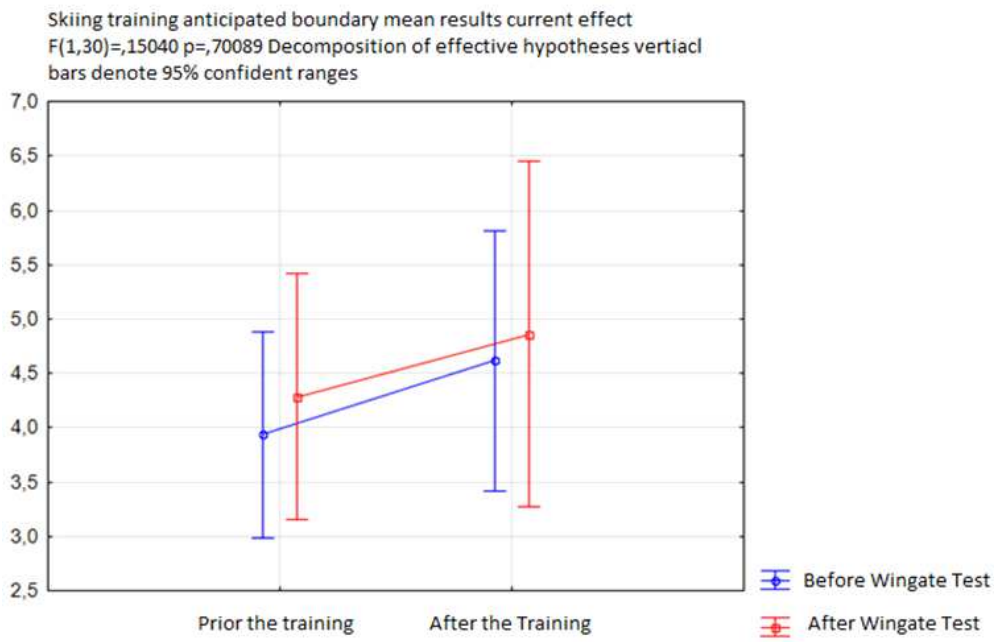

Fig. 3. Standard deviation of the time series of middle of foot pressure prior to and following ski training and before and after completing Wingate Test [mm]

The effect of fatigue after completing the Wingate Test and its impact on balance control appears to be considerably greater for trials performed prior to the ski training. The regression expressed in terms of the standard deviation of the time series for the trials performed following the training demonstrates the subjects' adaptation to anaerobic effort.

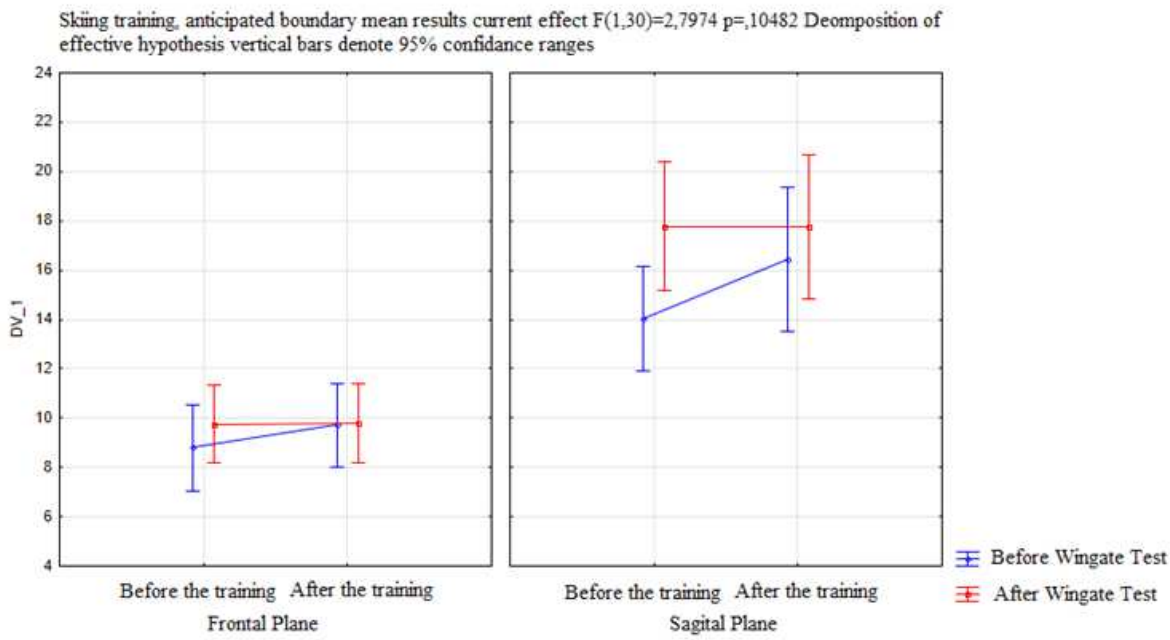

Fig. 4. Changes in standard deviation of the time series representing foot center of pressure prior to and following ski training according to planes [mm]

For the case of trials performed prior to the ski training, the completion of the Wingate Test had a more considerable impact on the results of the standard deviation of the time series of the of foot center of pressure and this effect was primarily due to greater oscillations in the frontal plane. In the case of the trials performed following the completion of the training program, the effect of fatigue proved to be of less importance and the results proved to be similar to each other.

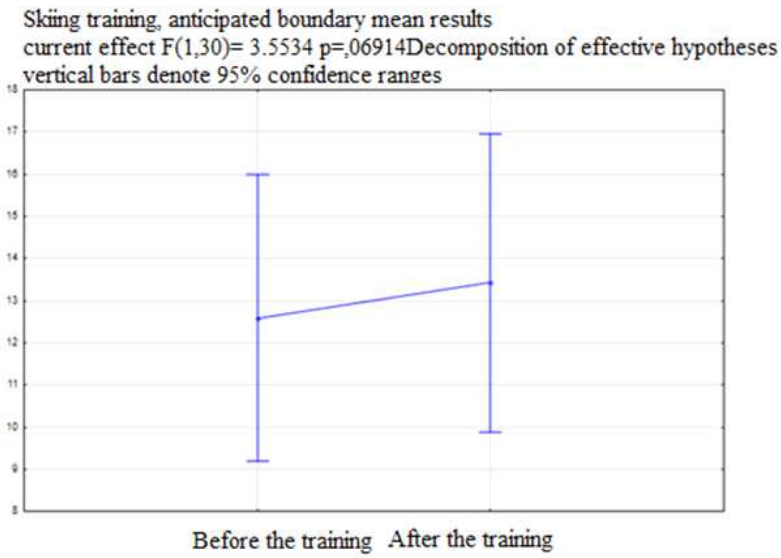

Fig. 5. Changes in mean velocity of the time series representing foot center of pressure prior to and following ski training [mm/s]

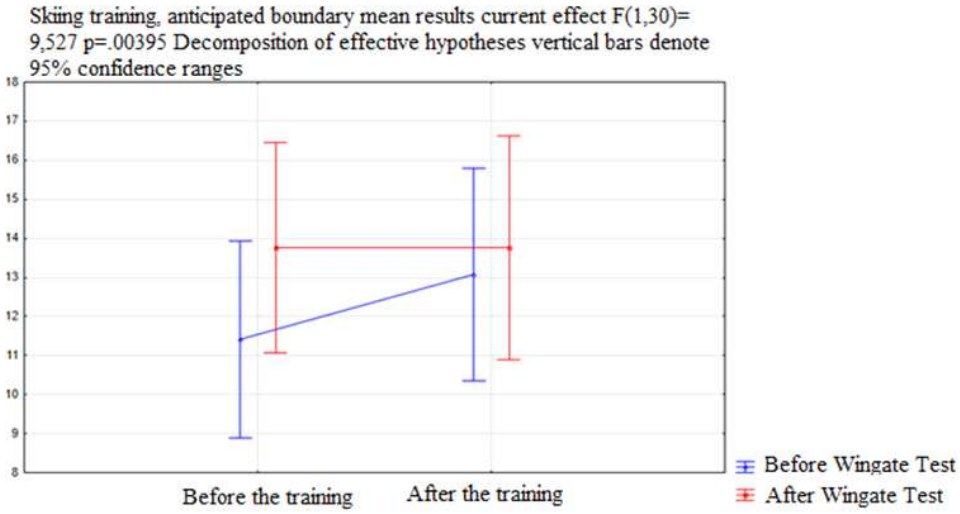

Fig. 6. Changes in mean velocity of the time series representing foot center of pressure prior to and following ski training and before and after completion of Wingate Test [mm/s]

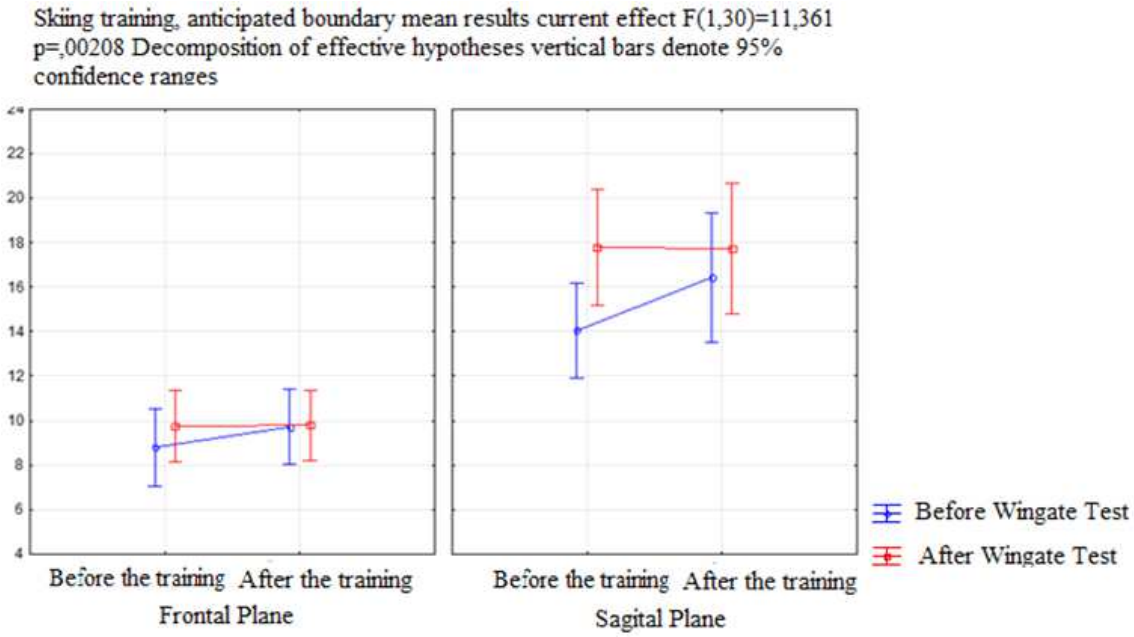

Fig. 7. Changes in mean velocity of the time series representing foot center of pressure prior to and following skiing training and before and after completion of Wingate Test according to planes [mm/s]

As with the case of standard deviation, for mean velocity the effect of the anaerobic test for trials performed prior to the ski training resulted in a more considerable increase of the mean velocity of the time series in comparison to the results recorded after completion of the ski training.

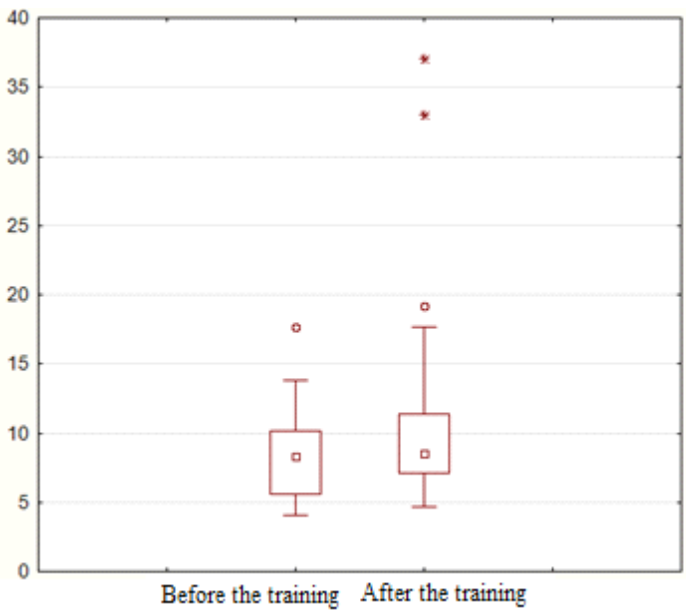

Fig. 8. Changes in mean velocity of the time series representing foot center of pressure prior to and following ski training for trials performed with open eyes while wearing ski boots, frontal plane [mm/s]

The results gained for trials performed with open eyes while wearing ski boots demonstrate that the level of balance control deteriorated, with a note that the results are not statistically significant.

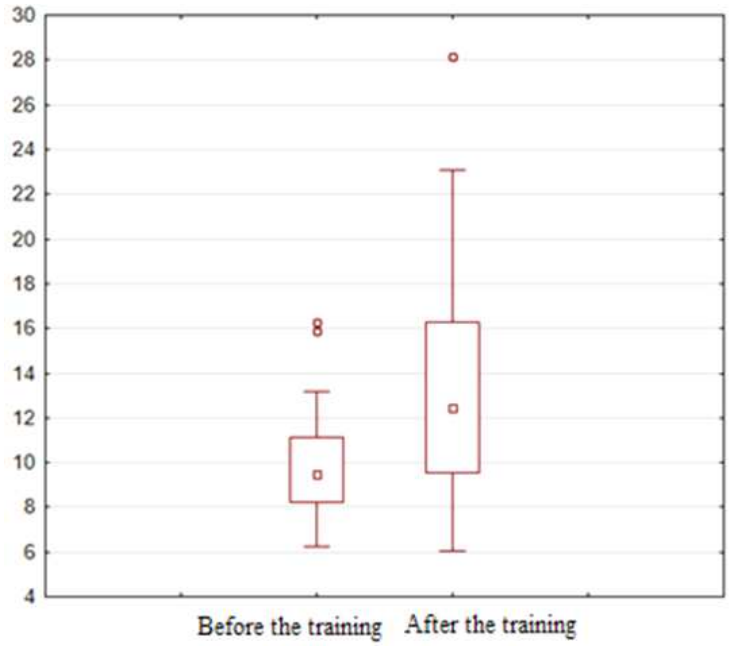

Fig. 9. Changes in mean velocity of the time series representing foot center of pressure prior to and following ski training for trials performed with open eyes barefoot, sagittal plane[mm/s]

For trials performed with open eyes while barefoot, the results in the sagittal plane demonstrate an improvement of the results in terms of the mean velocity.

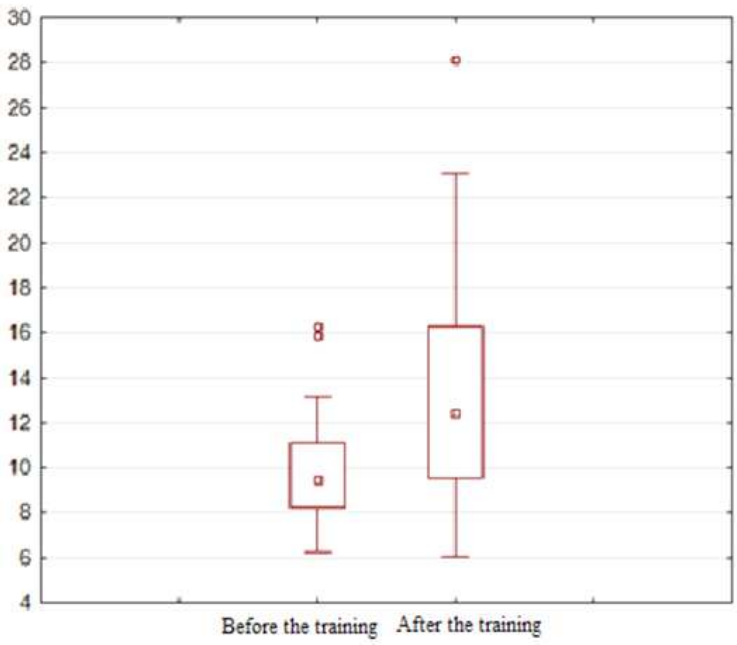

Fig. 10. Changes in mean velocity of the time series representing foot center of pressure prior to and following ski training for trials performed with closed eyes barefoot, frontal plane [mm/s]

The results demonstrate that the decrease of regression resulting from performing the exercise capacity test is primarily attributable to the movements in the frontal plane. The results for the sagittal plane are similar, yet the effect is not so visible.

The following aspect of the balance assessment applied the results of the correlation between the results of the Haczkiewicz Test and the results gathered through the use of a Kistler Force Plate. The results are presented in Table 3.

Table 3. Correlation between the results of the Haczkiewicz Test and selected parameters gathered using the Kistler force plate

Exercise	Parameter	Plane	Correlation coefficient
Trial prior to ski training – eyes closed, barefoot	Mean velocity of time series representing foot center of pressure [mm/s]	ap	0.42
Trial prior to ski training after Wingate test– eyes closed, wearing boots	Standard deviation of time series [mm]	ml	0.44
Trial prior to ski training after Wingate test– eyes open, wearing boots	Mean velocity of time series representing foot center of pressure [mm/s]	ml	0.42

The results of the Pearson correlation demonstrate an average dependency between the results of the Haczkiewicz test for the trials performed prior to skiing training, since in one trial, the existence of a dependence was established for the sagittal plane, whereas in the other trial – for the frontal plane. A similar level of correlation can be established for the trials performed following ski training after completion of the Wingate Test.

Discussion

The effect of balance control on skiing performance and the ability to gain new skills seems to be beyond any doubt, due to the very characteristics of this sport. This effect is confirmed by studies by Golema (1), who demonstrated that the process of restoring upright position to a deflected posture is similar to the maneuver performed by a skier at the phase when they steer the body to turn. However, in the process of implementing actual aspects of skiing or snowboarding, as well as during the process of assessing the effect it plays on balance control, it appears that the results are not that uniform.

The study performed by Tchórzewski (5) confirms the effect of practicing skiing disciplines on the level of balance control; yet, the results do not contain a clear statement as to whether this effect involves an improvement or deterioration of the results. The study by Mildner (4) demonstrates some level of improvement in this regard combined with differences between the skiers who practice this sport professionally and leisure skiers. The scope of the study by Wojtyczek (8) is closest to the present study in the sense that the present one focuses on the improvement in the control of the position of the body's center of mass represented by ground reaction force vector among subjects following ski training.

The issue of the control of the position of the body's center of mass represented by ground reaction force vector was also undertaken by Waśkiewicz (7), who demonstrated a decrease in the control for trials performed after completing the Wingate Test twice; however, it contains a

note that after subjects performed the anaerobic test three times, the decrease was not observed.

The research conducted for the purposes of the present study was based on the combination of methodologies developed in three studies. These included the contribution of Tchórzewski's study into applied trials performed in ski boots, Waśkiewicz's study, which offered the idea of the use of the fatigue aspect resulting from the completion of an anaerobic test, and the study by Wojtyczek, which provided the option of performing two test cycles that are separated by ski training.

The impact of the Wingate Test on the deterioration of the results in the subjects confirms the result gained by Waśkiewicz. However, an interesting conclusion is associated with the effects of ski training, which reduced the negative impact of post-exercise fatigue on the balance control results. In terms of the remaining aspects, the effect was negative, in particular in the frontal plane, in which the movement is described as similar according to the study by Golema (1).

This study was carried out on young subjects, who are physically fit at least to an intermediate level according to Nowak's study (5), although the effects of this characteristic on the present research was small. However, the existing correlation between the results of the Haczkiewicz Test and the results of trials performed following ski training means that the effect of the balance control on the ability to gain new skiing skills is moderate.

Summary and conclusions

The results of this study demonstrate that the parameters related to balance for which a dependence can be established with skiing practice include:

1. Mean velocity of the time series representing foot center of pressure for the frontal plane, with subjects wearing ski boots and with their eyes open,
2. Mean velocity of the time series representing foot center of pressure for the sagittal plane, with subjects barefoot and with their eyes open,
3. Mean velocity of the time series representing foot center of pressure for the frontal plane with subjects barefoot and with their eyes closed.

The analysis of the study results also leads to the conclusion that the effects of short-term skiing or snowboarding training on the subjects' balance systems is represented by a slight deterioration in some aspects of balance.

The anaerobic effort performed by the subjects resulted in a considerable level of deterioration of the balance parameters in all trials. Subsequently, following the short ski training this effect decreased, as the fatigue associated with the completion of an anaerobic test results in a smaller effect on the balance system of the tested subjects

In conclusion, the completion of skiing training has an effect on the control of the body's center of mass, yet this effect was negative. However, we can note the smaller effect of the Wingate Test on the regression of the results in the trials which is due to the completion of the ski training and a moderate correlation between the results of the test performed on the Kistler force plate and further results of the Haczkiewicz Test, which suggest the effect of the initial level of control over the body's center of mass on the ability to acquire new skiing skills among the subjects.

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