The impact of an intensive alpine skiing course on the ability to optimally use the muscle strength of physical education students

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- **A** Study Design
- **B** Data Collection
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Abstract

Background & Study Aim: Alpine skiing is a physical activity that stimulates (develops and maintains) primarily coordination skills, mainly the balance of the body, and also ability to kinaesthetic differentiation. An innovative method of measuring the ability to optimally use the muscle strength (AOUMS) of lower limbs is recommended. The purpose of this study is to answer the question whether students after the alpine skiing course will improve ability to optimally use the muscle strength of lower limbs.

Material & Methods: The study included a group of eleven students (5 women and 6 men) who participated in an alpine skiing course were examined. The basic skiing course lasted 10 days: 7 teaching hours (45 minutes each) a day. The method used was this recommended by Kalina (2021): 'diagnostic exercise systems'. Diagnosis of lower limb AOUMS (non-apparatus version): long jump from standing posture. Patterns of force use in diagnosing lower limbs were used (the first exercise with eyes open, the second exercise eyes covered) and then alternated: 50%, 25%, 75%, 50% , 35%, 85%. The series of six exercises ended with three trials with open eyes, each at 100% (the farthest jump was the frame of reference for measuring the conformity of each score to the model expressed in %). The subjects had no prior knowledge of the methods. Body composition was measured device Tanita 525N.

Results: The fourth-ranked student before the alpine skiing course Index AOUMS for lower limbs was 16.11+, and under the influence of specific measures and new motor experiences related to learning skiing, it decreased to 5.72+&− (she became the leader of the results at the end of the course) .The phenomenon turned out to be bipolar: the leader from before the course (10.55+) with the result of alpine skiing 63.58+ moved to the penultimate ranking position after the course. This, in a way, paradox of results migration is not isolated and divides students into two groups in this respect. Four students improved their results, while seven worsened. The factor that differentiated the two groups was the fact that the training of the four was conducted by an instructor with 39 years of experience, while the other with only three years. This, however, is not a sufficient argument for unambiguous inference of the reasons.

Conclusions: The diagnostic exercise system used (non-apparatus version) turned out to be a sensitive and simple tool for measuring AOUMS changes under the influence of intense stimuli burdening the lower limbs with many hours and many days of physical effort.

Keywords: innovative agonology • non-apparatus version of diagnostic exercise systems • ranking position • Tanita 525N

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PE – Physical Education.

Microcycle – shortest training cycle is characterising by the dynamic of loads occurring in 5 to 9 days (usually a week).

Alpine skiing – *noun* skiing on steep mountain courses, rather than across country [20].

Proprioception – sensory information that comes primarily from sources in the muscles and joints and from bodily movements [10].

Non-apparatus test – that motoric test (exercise endurance test) of the required reliability (accurate and reliable), which use does not require even the simplest instruments [19].

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [19].

INTRODUCTION

The phenomenon of the ability to optimally use muscle strength (AUOMS) was described by Kalina and concerned the measurement of the muscle strength of the lower [1] and upper limbs [2]. Examination of lower limbs AOUMS comes down to simple, easy-to-use sets of exercises – measurement falls into the non-apparatus category, while upper limb to quasi-apparatus category. In addition, the ability to alternate the use of open and shielded eyes during testing is important from a cognitive standpoint. An important methodological aspect is the measurement of maximum muscle strength of the lower extremities, which is performed with the eyes open, only during the three exercises completing the applied 'sets of exercises diagnosing'. Author consider AUOMS as an essential element, of the phenomenon of kinesthetic differentiation ability, and is related to proprioception [1]. AOUMS measurement can be used in the practice of sports training or in any other area of human activity (rehabilitation, professional work, etc.). A firefighter, policeman, soldier, etc., when working, must use optimal muscle strength to perform the task perfectly. In sports, too, the use of adequate muscle strength determines success or lack thereof. Many physical activities require the use of optimal muscle strength in both the lower and upper extremities.

Alpine skiing is a physical activity that stimulates ability to kinesthetic differentiation and balance of the body [3]. These abilities are necessary to make the process of teaching, as well as independent skiing, safe. An experienced instructor, even if he or she cannot explain the phenomenon scientifically, can conduct rational training and use appropriate tests. Regular, methodologically correct testing can modify the training process in professional skiing, but primarily serve to improve safety during initial teaching. Innovative agonology [4, 5] provides unique tools for diagnosing phenomena qualifying for kinesthetic differentiation: the body balance disturbances tolerance skill ('Rotational Test' – RT [6] and the ability to optimally use the muscle strength of limb ('sets of exercises diagnosing AOUMS' – lower limb [1]; upper limb [2].

The purpose of this study is to answer the question whether students after the alpine skiing course will improve ability to optimally use the muscle strength of lower limbs.

MATERIAL AND METHODS

Participants

The study included a group of eleven (5 women and 6 men) physical education (PE) students (171.9±7.29 cm; 69.37±9.53kg) who participated in an alpine skiing course. From this group 5 students training ball sports (football, volleyball), 6 not practicing sports.

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Study design

The students were tested before and after the basic alpine skiing course lasted 10 days: 7 teaching hours (45 minutes each) a day.

'Diagnostic Exercise Arrangement' model execution "2 × 160 UMS"

Assumption of this model is to use 160% of muscle force twice each, three times with eyes open, three times with eyes covered (6 exercises in total) in an order known only to the examiner, alternating eyes open, eyes covered). Estimation of maximum force is based on performing the last three jumps with eyes open with a sense of the greatest energy exposure (each jump separated by about a 20-second pause), with the longest just being the 100% criterion. We used the model recommended by Kalina [1]: 50%; 25%; 75%; 50%; 35%; 85%; three times 100%. The subject is first verbally acquainted with the essence of the pending exercise system, with a clear articulation that it is about his perceived energy potential at that moment, which will be estimated precisely by a series of these jumps. After declaring that she understands the tasks, she stands in front of the line in a slight stride and, after the command "READY", performs the jumps in sequence according to the accepted model (but known only to the researcher). After making a jump in front of a fixed line, the test subject turns on the heel of the foot closer to the starting line, and the measure of distance is the number of feet. If the last foot either crosses the starting line or does not make contact with it, the distance should be subjectively estimated to the nearest 0.1 of the length of that foot; the raw result should be recorded, e.g. 6.4 [1].

The estimated compliance or error (in %) is the result of, first, determining the UMS value during the evaluated test (dividing the raw result of that test by the raw maximum result), and then comparing the performance (that is, this result with the model). An error-free result is documented with an "x" symbol in a special test sheet (appendix: *long jump from standing posture*), while the use of excessive force is documented with a "+" symbol placed after the recorded result, and in the case of a force deficiency with a "–" symbol [1].

The muscle strength indicator (UMS) in relation to the model value is the proportion of exercises whose error in relation to the model value is not greater than 5% to the number of exercises of a given diagnostic system. In the model used, there are 6 of these exercises (3 for open eyes and 3 for covered eyes). Index UMS for 6 exercises: very high 1 and 0.83; high 0.667; average 0.50; low 0.33; very low 0.167; insufficient 0.00. The absolute compliance of the performed exercises with the model or with errors of less than one percent would mean an outstanding level of AOUMS [1].

Body composition

We based the characteristics of the body composition on the recommended indicators: body height (cm), body weight (kg), BMI (body max index), body fat (%), body water (%), muscles (kg), bones, visceral fat (range) [7, 8]. Body composition was measured device Tanita 545N.

Statistical analysis

The estimation of the results is based on the following indicators: frequency (n); mean; minimum (Min); Maximum (Max); standard deviation. The Pearson correlation coefficient between pairs of specified variables was calculated.

The ordinal variable when determining the ranking positions (RP) of the subjects was always the smaller value of the estimated error or the sum of the errors of the analysed indicator (conformity of the result to the model). The main ordinal variable (sum of Index AOUMS) was the value of the Index AOUMS for lower limbs.

RESULTS

The fourth-ranked students (code PE-S4 and PE-S5, but the same RP: 4a and 4b respectively) before the alpine skiing course sum of Index AOUMS for lower limbs was 16.11+ (Table 1 and 2). The female student PE-S5 under the influence of specific measures and new motor experiences related to learning skiing – her sum of Index AOUMS it decreased to 5.72+&– (Table 3) and she became the leader of the results at the end of the course (Table 4).

The phenomenon turned out to be bipolar: the leader from before the course (10.55+) with the result of alpine skiing 63.58+ moved to the penultimate ranking position after the course (Table 5). This, in a way, paradox of results migration is not isolated and divides students into two groups in this respect. Four students improved their results – reduced the error scale. (Table 6), while seven worsened (Table 7).

Body composition indices do not clearly differentiate between the students of the two subgroups (Table 8 and 9). Admittedly, the high correlation coefficients of the subgroup that improved the score (found only before alpine skiing course) between Index AOUMS and part of the body composition indices are rather coincidental (Table 10). Even more so one significant correlation in the subgroup that made more test errors after course.

Table 1. Ranking position (RP) of the PE students according to the ordinal variable: from the lowest total (sum) value of the Index AOUMS before alpine skiing course.

RP	Person	Difference model-execution "2 × 160 UMS"			
		sum of Index AOUMS	the use of muscle strength (UMS)	Index AOUMS for:	
				eyes open	eyes covered
1	PE-S1	**10.55+**	tendency to UMS abuse	**9.44+**	**1.11+**
2	PE-S2	**10.6+&–**	UMS quality modified by circumstances	**5.15+**	**5.45–**
3	PE-S3	**11.67+&–**	UMS quality modified by circumstances	**1.67+**	**10.0–**
4a	PE-S4	**16.11+**	tendency to UMS abuse	**9.44+**	**6.67+**
4b	PE-S5	**16.11+**	tendency to UMS abuse	**6.67+**	**9.44+**
5	PE-S6	**26.55+**	tendency to UMS abuse	**3.79+**	**22.76+**
6	PE-S7	**41.67+**	tendency to UMS abuse	**35.0+**	**6.67+**
7	PE-S8	**44.52+**	tendency to UMS abuse	**28.71+**	**15.81+**
8	PE-S9	**56.98–**	tendency to UMS deficiency	**20.27–**	**36.71–**
9	PE-S10	**57.11+**	tendency to UMS abuse	**20.72+**	**36.39+**
10	PE-S11	**63.07–**	tendency to UMS deficiency	**6.15–**	**56.92–**

Table 2. The results of PE students listed by ordinal variable: from the lowest total value of Index AOUMS before alpine skiing course (see Table 1).

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	Profile AOUMS
		below x%	50%	over x%	sum		
PE-S1 (total value of Index AOUMS 10.55+)							
lower limbs	Open	9.44+	**2.78*+**	**2.78*–**	15.0+&–	9.44+	low (0.33 Index) AOUMS; tendency to UMS abuse
	Covered	9.72+	6.94+	15.56–	32.22+&–	1.11+	
	Sum	19.16+	9.72+	18.34–	47.22+&–	**10.55+**	
PE-S2 (total value of Index AOUMS 10.6+&–)							
lower limbs	Open	13.48+	**1.52*–**	6.82–	21.82+&–	5.15+	low (0.33 Index) AOUMS; UMS quality modified by circumstances
	Covered	6.82+	**4.55*+**	16.82–	28.19+&–	5.45–	
	Sum	20.3+	6.07+&–	23.64–	50.01+&–	**10.6+&–**	
PE-S3 (total value of Index AOUMS 11.67+&–)							
lower limbs	Open	20.0+	**0.00****	18.33–	38.33+&–	1.67+	average (0.50 Index) AOUMS; UMS quality modified by circumstances
	Covered	**3.33*+**	**0.00****	13.33–	16.66+&–	10.0-	
	Sum	23.33+	0.00	31.66–	54.99+&–	**11.67+&–**	

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	Profile AOUMS
		below x%	50%	over x%	sum		
PE-S4 (total value of Index AOUMS 16.11+)							
lower limbs	Open	8.06+	**1.39*+**	**0.00****	9.45+	9.44+	low (0.33 Index) AOUMS; tendency to UMS abuse
	Covered	9.72+	5.56+	8.61–	23.89+&–	6.67+	
	Sum	17.78+	6.95+	8.61–	33.34+&–	**16.11+**	
PE-S5 (total value of Index AOUMS 16.11+)							
lower limbs	Open	13.61+	8.33–	**1.39*+**	23.33+&–	6.67+	low (0.33 Index) AOUMS; tendency to UMS abuse
	Covered	**2.78*+**	15.28+	8.61–	26.67+&–	9.44+	
	Sum	16.39+	23.61+&–	10.0+&–	50.0+&–	**16.11+**	
PE-S6 (total value of Index AOUMS 26.55+)							
lower limbs	Open	0.52**–	1.72*+	2.59*+	4.83+&–	3.79+	high (0.667 Index) AOUMS; tendency to UMS abuse
	Covered	18.10+	8.62+	3.79*–	30.51+&–	22.76+	
	Sum	18.62+&–	10.34+	6.38+&–	35.34+&–	26.55+	
PE-S7 (total value of Index AOUMS 41.67+)							
lower limbs	Open	23.33+	8.33+	**3.33*+**	34.99+	35.0+	low (0.33 Index) AOUMS; tendency to UMS abuse
	Covered	**3.33*+**	16.67+	13.33–	33.33+&–	6.67+	
	Sum	26.66+	25+	16.66+&–	68.32+&–	**41.67+**	
PE-S8 (total value of Index AOUMS 44.52+)							
lower limbs	Open	8.55+	8.06+	12.1+	28.71+	28.71+	low (0.33 Index) AOUMS; tendency to UMS abuse
	Covered	**2.42*+**	**4.84*+**	8.55+	15.81+	15.81+	
	Sum	10.97+	12.9+	20.65+	44.52+	**44.52+**	
PE-S9 (total value of Index AOUMS 56.98–)							
lower limbs	Open	**3.49*–**	**0.68**–**	16.1–	20.27–	20.27–	low (0.33 Index) AOUMS; tendency to UMS deficiency
	Covered	7.19–	18.49–	11.03–	36.71–	36.71–	
	Sum	10.68–	19.17–	27.13–	56.98–	**56.98–**	
PE-S10 (total value of Index AOUMS 57.11+)							
lower limbs	Open	**1.14*+**	**4.22*+**	15.63+	20.99+	20.72+	average (0.50 Index) AOUMS; tendency to UMS abuse
	Covered	17.17+	19.88+	**0.66**–**	37.71+&–	36.39+	
	Sum	18.31+	24.1+	16.29+&–	58.7+&–	**57.11+**	
PE-S11 (total value of Index AOUMS 63.07–)							
lower limbs	Open	18.85+	11.54–	13.46–	43.85+&–	6.15–	insufficient (0.00 Index) AOUMS; tendency to UMS deficiency
	Covered	9.62–	19.23–	28.08–	37.7–	56.92–	
	Sum	28.47+&–	11.54–	41.54–	81.55+&–	**63.07–**	

Table 3. Ranking position (RP) of the PE students according to the ordinal variable: from the lowest total (sum) value of the Index AOUMS after alpine skiing course.

RP	Person code	Difference model-execution "2 × 160 UMS"			
		sum of Index AOUMS	the use of muscle strength (UMS)	Index AOUMS for:	
				eyes open	eyes covered
1	PE-S5	**5.72+&–**	UMS quality modified by circumstances	**2.86–**	**2.86+**
2	PE-S9	**11.62+**	tendency to UMS abuse	**0.98+**	**10.73+**
3	PE-S4	**21.36–**	tendency to UMS deficiency	**10.68–**	**10.68–**
4	PE-S2	**36.37+&–**	UMS quality modified by circumstances	**1.82–**	**34.55+**
5	PE-S11	**38.89+&–**	UMS quality modified by circumstances	**12.22+**	**26.67–**
6	PE-S3	**43.08+&–**	UMS quality modified by circumstances	**23.08–**	**20.0+**
7	PE-S6	**43.81–**	tendency to UMS deficiency	**18.73–**	**25.08–**
8	PE-S10	**48.0+**	tendency to UMS abuse	**26.67+**	**21.33+**
9	PE-S8	**50.13+**	tendency to UMS abuse	**30.91+**	**19.22+**
10	PE-S1	**63.58+**	tendency to UMS abuse	**34.03+**	**29.55+**
11	PE-S7	**97.65+**	tendency to UMS abuse	**61.57+**	**36.08+**

Table 4. The results of PE students listed by ordinal variable: from the lowest total value of Index AOUMS after alpine skiing course (see Table 3).

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	Profile AOUMS
		below x%	50%	over x%	sum		
PE-S5 (total value of Index AOUMS 5.72+&–)							
lower limbs	Open	**5.0*+**	**0.00****	7.86–	12.86+&–	2.86–	low (0.33 Index) AOUMS; UMS quality modified by circumstances
	Covered	7.86+	10.0+	15.0–	32.86+&–	2.86+	
	Sum	12.86+	10.0+	22.86–	45.72+&–	**5.72+&–**	
PE-S9 (total value of Index AOUMS 11.62+)							
lower limbs	Open	10.12+	**4.88*–**	**4.27*–**	19.27+&–	0.98+	high (0.667 Index) AOUMS; tendency to UMS abuse
	Covered	7.93+	**4.88*+**	**2.07*–**	14.88+&–	10.73+	
	Sum	18.05+	9.76+&–	6.34–	34.15+&–	**11.62+**	
PE-S4 (total value of Index AOUMS 21.36–)							
lower limbs	Open	**1.99*+**	**2.05*–**	10.62–	14.66+&–	10.68–	average (0.50 Index) AOUMS; tendency to UMS deficiency
	Covered	35.27+	**4.79*+**	50.75–	90.81+&–	10.68–	
	Sum	37.26+	6.84+&–	61.37–	105.47+&–	**21.36–**	

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	Profile AOUMS
		below x%	50%	over x%	sum		
PE-S2 (total value of Index AOUMS 36.37+&–)							
lower limbs	Open	10.45+	**2.73*–**	9.55–	22.73+&–	1.82–	low (0.33 Index) AOUMS; UMS quality modified by circumstances
	Covered	20.45+	11.82+	**2.27*+**	34.54+	34.55+	
	Sum	30.9+	14.55+&–	11.82+&–	57.27+&–	**36.37+&–**	
PE-S11 (total value of Index AOUMS 38.89+&–)							
lower limbs	Open	9.44+	5.56+	**2.78*–**	17.78+&–	12.22+	low (0.33 Index) AOUMS; UMS quality modified by circumstances
	Covered	12.5+	**1.39*+**	40.56–	54.45+&–	26.67–	
	Sum	21.94+	6.95+	43.34–	72.23+&–	**38.89+&–**	
PE-S3 (total value of Index AOUMS 43.08+&–)							
lower limbs	Open	**1.15*–**	**3.85*–**	18.08–	23.08–	23.08–	average (0.50 Index) AOUMS; UMS quality modified by circumstances
	Covered	**1.92*–**	6.92+	15.0+	23.84+&–	20.0+	
	Sum	3.07–	10.77+&–	33.08+&–	46.92+&–	**43.08+&–**	
PE-S6 (total value of Index AOUMS 43.81–)							
lower limbs	Open	8.02–	7.14–	**3.57*–**	18.73–	18.73–	very low (0.167 Index) AOUMS; tendency to UMS deficiency
	Covered	8.33+	8.73–	24.68–	41.74+&–	25.08–	
	Sum	16.35+&–	15.87–	28.25–	60.47+&–	**43.81–**	
PE-S10 (total value of Index AOUMS 48.0+)							
lower limbs	Open	9.0+	11.33+	6.33+	26.66+	26.67+	insufficient (0.00 Index) AOUMS; tendency to UMS abuse
	Covered	21.67+	8.86+	9.0–	39.53+&–	21.33+	
	Sum	30.67+	20.19+	15.33+&–	66.19+&–	**48.0+**	
PE-S8 (total value of Index AOUMS 50.13+)							
lower limbs	Open	6.56+	14.94+	9.42+	30.92+	30.91+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	Covered	8.77+	11.04+	**0.58**–**	20.39+&–	19.22+	
	Sum	15.33+	25.98+	10+&–	51.31+&–	**50.13+**	
PE-S1 (total value of Index AOUMS 63.58+)							
lower limbs	Open	17.24+	6.27+	10.07+	33.58+	34.03+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	Covered	10.82+	18.66+	**0.07**+**	29.55+	29.55+	
	Sum	28.06+	24.93+	10.14+	63.13+	**63.58+**	
PE-S7 (total value of Index AOUMS 97.65+)							
lower limbs	Open	37.55+	18.63+	5.39+	61.57+	61.57+	insufficient (0.00 Index) AOUMS; tendency to UMS abuse
	Covered	24.02+	18.63+	6.57–	49.22+&–	36.08+	
	Sum	61.57+	37.26+	11.96+&–	110.79+&–	**97.65+**	

Table 5. Migration of RP (ordinal variable 'before') PE students (n = 11) as a result of adaptive effects of AOUMS caused by psychophysical effort loads during a 10-day alpine skiing course (grey rows – reduced error scale).

Person		RP		Index AOUMS		Difference of AOUMS
code	gender	before	after	before	after	
PE-S1	male	1	10	**10.55+**	**63.58+**	**53.03**
PE-S2	female	2	4	**10.6+&–**	**36.37+&–**	**25.77**
PE-S3	female	3	6	**11.67+&–**	**43.08+&–**	**31.41**
PE-S4	male	4a	3	**16.11+**	**21.36–**	**5.25**
PE-S5	female	4b	1	**16.11+**	**5.72+&–**	**10.39**
PE-S6	female	5	7	**26.55+**	**43.81–**	**17.26**
PE-S7	female	6	11	**41.67+**	**97.65+**	**55.98**
PE-S8	male	7	9	**44.52+**	**50.13+**	**5.61**
PE-S9	male	8	2	**56.98–**	**11.62+**	**45.36**
PE-S10	male	9	8	**57.11+**	**48.0+**	**9.11**
PE-S11	male	10	5	**63.07–**	**38.89+&–**	**24.18**

Table 6. The difference between the results of PE students (n = 4), who reduced the error scale.

Person		Index AOUMS			
code	gender	before	after	difference	RP
PE-S10	male	**57.11**	**48**	**9.11**	1
PE-S5	female	**16.11**	**5.72**	**10.39**	2
PE-S11	male	**63.07**	**38.89**	**24.18**	3
PE-S9	male	**56.98**	**11.62**	**45.36**	4
Mean		**48.32**	**26.06**	**22.26**	
SD		21.66	20.56	16.84	
Min		16.11	5.72	9.11	
Max		63.07	48.00	45.36	

Table 7. The difference between the results of PE students (n = 7) who increased the error scale.

Person		Index AOUMS			
code	gender	Before	after	difference	RP
PE-S4	male	**16.11**	**21.36**	**5.25**	1
PE-S8	male	**44.52**	**50.13**	**5.61**	2
PE-S6	female	**26.55**	**43.81**	**17.26**	3

Person		Index AOUMS			
code	gender	Before	after	difference	RP
PE-S2	female	**10.6**	**36.37**	**25.77**	4
PE-S3	female	**11.67**	**43.08**	**31.41**	5
PE-S1	male	**10.55**	**63.58**	**53.03**	6
PE-S7	female	**41.67**	**97.65**	**55.98**	7
Mean		**23.10**	**50.85**	**27.76**	
SD		14.77	24.30	20.66	
Min		10.55	21.36	5.25	
Max		44.52	97.65	55.98	

Table 8. Body composition indicators for PE students (n = 4), who reduced the scale of errors – ordinal variable: difference of Index AOUMS before and after alpine skiing course (see Table 6).

RP	Student code	Sport discipline	Body height (cm)	Body weight (kg)	BMI	Body fat (%)	Body water (%)	Muscles (kg)	Bones	Visceral fat (range)
1	PE-S10	football	170	71.7	24.8	13.9	62.6	58.7	3.1	2
2	PE-S5	football	162	57.5	21.9	26.4	55	40.2	2.2	1.5
3	PE-S11	football	173	83.9	28	18.3	60.2	65.1	3.4	6.5
4	PE-S9	none	186	75.4	21.8	8.7	65.2	65.5	3.4	1
Mean			**172.75**	**72.13**	**24.13**	**16.83**	**60.75**	**57.38**	**3.03**	**2.75**
SD			9.98	11.01	2.93	7.49	4.34	11.87	0.57	2.53
Min			162	57.5	21.8	8.7	55	40.2	2.2	1
Max			186	83.9	28	26.4	65.2	65.5	3.4	6.5

Table 9. Body composition indicators for PE students (n = 7), who increased the scale of errors – ordinal variable: difference of Index AOUMS before and after alpine skiing course (see Table 7).

RP	Student code	Sport discipline	Body height (cm)	Body weight (kg)	BMI	Body fat (%)	Body water (%)	Muscles (kg)	Bones	Visceral fat (range)
1	PE-S4	none	170	68.4	23.6	15.4	60.5	57.4	2.9	2
2	PE-S8	none	175	75.8	24.7	17.2	59.2	59.6	3.1	3.5
3	PE-S6	none	173	61.5	20.6	22	57	45.6	2.4	1
4	PE-S2	volleyball	178	82.7	26.1	30.4	50.5	54.7	2.9	2.5
5	PE-S3	none	166	61.1	22.2	23.9	56.6	44.2	2.4	1

RP	Student code	Sport discipline	Body height (cm)	Body weight (kg)	BMI	Body fat (%)	Body water (%)	Muscles (kg)	Bones	Visceral fat (range)
6	PE-S1	football	169	68.5	24	14.2	62	55.8	2.9	2.5
7	PE-S7	none	160	56.6	22.1	19.5	61.2	43.1	2.3	1
Mean			**170.14**	**67.80**	**23.33**	**20.37**	**58.14**	**51.49**	**2.70**	**1.93**
SD			5.98	9.10	1.84	5.62	3.94	6.93	0.32	0.98
Min			160	56.6	20.6	14.2	50.5	43.1	2.3	1
Max			178	82.7	26.1	30.4	62	59.6	3.1	3.5

Table 10. Correlation of the 'Index AOUMS' before and after alpine skiing course with body composition indices of PE students, who reduced (n = 4) and increased (n = 7) the scale of errors.

Index AOUMS	Body composition indicator							
	body height (cm)	body weight (kg)	BMI	body fat (%)	body water (%)	muscles (kg)	bones	visceral fat (range)
PE students who reduced the scale of errors (n = 4)								
before	0.679	**0.936****	0.601	−0.786	**0.822****	**0.972****	**0.976****	0.449
after	−0.048	0.577	0.792	−0.265	0.322	0.492	0.509	0.527
PE students who increased the scale of errors (n = 7)								
before	−0.207	−0.224	−0.214	−0.265	0.355	−0.089	−0.101	0.104
after	**−0.677***	−0.496	−0.261	−0.189	0.440	−0.462	−0.444	−0.239

*p<0.05; **p<0.01

The students who reduced errors used excess strength with their eyes open (before and after the course) when the tasks were 35%. With blindfolded eyes (criterion 25%), they repeated this error only after the course. Similar UMS deficiency was documented with eyes closed (85% criterion) before and after the course (Figure 1). The phenomenon is based on similar characteristics in the case of students who have magnified errors after the course (Figure 2).

DISCUSSION

The results of the statistical analysis revealed a slight tendency to increase the magnitude of errors under the influence of psychophysical exertion loads during the observed downhill skiing course of PE students who had no such motor experience before. The proportion of those with this tendency is 7 to 4 of those who reduced errors during the application of AOUMS lower limb. A more in-depth qualitative analysis of the results further reveals that there is greater inter-individual variation among these 7 students (range Index AOUMS = 50.73) than those who reduced errors (range = 36.25) – no longer as clearly documented standard deviation. Only slightly, the influence of the factor of individual differences (genetic and shaped in the course of previous psychophysical activity of the students studied) is documented by an increased number of RPs (determined on the basis of Index AOUMS) after the course.

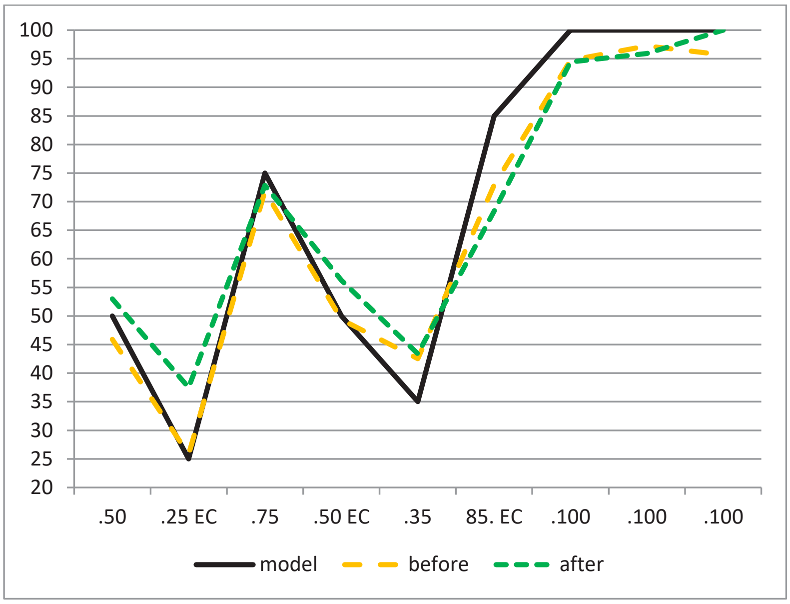

Figure 1. Profile of PE students (n = 4), who reduced the scale of errors (individually) in relation to the first examination (see Table 6, EC – eyes covered).

Figure 2. Profile of PE students (n = 7), who increased the scale of errors (individually) in relation to the first examination (see Table 7, EC – eyes covered).

The above observations do not exhaust the argument, admittedly documented by objective empirical data, about the possible causes of differential adaptation effects. A premise, but already of a subjective nature, that the teaching experience of ski instructors may have influenced the reduction of errors is the fact that all students who achieved this effect were taught by one with more than thirty years of experience.

However, in our opinion, it is not these results that have the greatest cognitive value, but the diagnostic potential of the innovative method used to measure the phenomenon of the ability to optimally use muscle strength of lower limbs, using such a simple tool and without the need for any apparatus [1]. The use of this tool makes it possible to diagnose AOUMS separately of the lower limbs, when circumstances warrant such a choice. However, the combination of both tools, that is, already with AOUMS upper limb (quasi-apparatus category [2]) is justified in many other circumstances.

A convincing example of the use of both of these tools (which measure AUOMS lower and upper limb) is given by their creator [2, p. 193]: *a simple example is the diverse motor activity of musicians. Both limbs are used by the drummer, pianist, organist, harpist. Both hands, but in different ways, a violinist, guitarist, contrabassist, etc. However, the solo violinist does his work standing, so it is reasonable to use both AOUMS models (for diagnosis of upper limbs and lower limbs) or new tools, but based on this methodological basis. A violinist, as well as another orchestral or chamber musician, performs their work sitting, so a version of AOUMS using a chair may be applicable.*

Alpine skiing is a physical activity in which, in a motor sense, the lower limbs play the most important role, but for technically correct skiing it is also necessary to use the upper limbs. Many sports (combat sports, racket sports, games, etc.) and daily physical activities, including professional activities, rely on the use of muscle strength of both lower and upper extremities. The main finding of our study, is that physical exertion (a 10-day alpine skiing course) caused an increase of the error scale by most PE students (63.63%).

This is, of course, too small sample from the population to draw generalizing conclusions, but on the other hand, this is the entire population of PE faculty students surveyed. If we take into account the result of a study of other PE students from a year ago (but also the entire population of the same PE faculty who took an identical alpine skiing course at the same facility), indicating a deterioration of the body balance disturbances tolerance skill (BBDTS) in most of them [3], there are at least two reasons to consider such an inference valid.

First, both phenomena, AOUMS lower limb and BBDTS, are identified with ability to kinaesthetic differentiation [9], proprioception [10], and certainly with the phenomenon of motor coordination, so the tools used are a secondary matter. In methodological terms, it is important to ascertain the direction of change. Secondly, lower limbs are involved in both motor tasks that differ in terms of movement structure. An earlier study by Litwiniuk et al. [3] used the 'Rotational Test' quasi-apparatus version, so the results are documented by the sum of points (errors estimated from 1 to 3) during the 6 test tasks and the time (s) of test execution. Among PE students practicing combat sports (n = 12), nobody reduced errors measured by the sum of points (especially that 7 did not make any) after skiing course, but on the contrary, 25% made more of them, and the rest (75%) repeated the result, while 33.33% performed RT faster, the rest in a longer time. In general, the score in points and measured by time are negatively correlated. The three students who performed RT faster simultaneously made more errors during the after skiing course test – he fourth again made no errors in the motor sense, but performed the test faster by 0.1 seconds. Among PE students practicing other physical activity (n = 12) three (25%) reduced errors, eight (66.66%) made more errors, and one repeated the score. The time to complete the test was reduced by 41.66%, the rest worsened the score.

Thus, the general conclusion that the implemented alpine skiing course model in the observed PE faculty, regardless of the students' previous motor experience, deteriorates their coordination abilities (especially the ability to kinaesthetic differentiation) is legitimate. This is, of course, an ad hoc effect, which can be linked to the phenomenon of fatigue caused by the intensive microcycle, during which learning new motor activities dominated. However, the multifaceted adaptive effects for the future are not known. Estimating this phenomenon is basically, with current knowledge and diagnostic capabilities, impossible. In order to determine to what extent the coordination potential (kinaesthetic differentiation) of these students has been altered, it would be necessary to document the numerous motor responses under circumstances of intended and forced (by external factors) physical activity that are difficult to quantify.

CONCLUSIONS

The diagnostic exercise system used (non-apparatus version) turned out to be a sensitive and simple tool for measuring AOUMS changes under the influence of intense stimuli burdening the lower limbs with many hours and many days of physical effort.

However, an abbreviated secondary analysis of some of the well-documented findings of Litwiniuk et al. [3] combined with two pertinent insights by Kruszewski and Litwiniuk [11] show, in addition to the diagnostic possibilities indicated, the prospect of their complementary use in modern prevention, therapy and rehabilitation based on the directives and methods of innovative agonology (among the most recent: 12, 1, 2, 13). Their postulate to include also Chinese health exercises with defensive qualities (e.g., tai chi) in one complex is justified by the results of recent review works [14-18].

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