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The Effects of Fitness Program in Increasing Physical Fitness for Alpine Skiing on Second-Year University Students

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Abstract: *Each individual achieves ease in performing a particular skiing element if he/she uses the multitude of available movement activities purposefully and harmoniously. Alpine skiing requires highly developed aerobic and anaerobic capacities, as well as high level of motor skills, which primarily include strength, explosiveness, agility, balance, flexibility and coordination. Group fitness programs are the most widespread form of sports recreation, and they have a positive effect on the transformation of the functional abilities of the organism and changes in body composition. This research was conducted 14 male participants aged 20-21, second-year students, with aim to determine whether the level of physical fitness can be improved by applying a group fitness program, which would open up the possibility of applying group fitness programs as sports and recreational activities in preparation for the implementation of alpine skiing lessons, but also as a program to increase the physical fitness of older populations for recreational alpine skiing. The fitness program used in this study was authored by Jim Stoppani, a 12-week program based on the concept of periodization and the concept of microcycles, and aimed to increase strength, increase muscle mass and reduce body fat. Statistic analysis showed that program has positive effects on morphological characteristics, functional abilities and motor abilities essential for alpine skiing.*

Keywords: *motor skills, sports and recreational activities, alpine skiing lessons.*

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Introduction

Skiing is a motor activity during which a skier overcomes a slope, mainly using different turning techniques (Matković et al., 2004). Anthropological characteristics also play an important role in this, of which the motor and functional abilities of alpine skiers should be particularly highlighted. In skiing, as in many other sports activities, there is a large number of different movements limited by the anatomical characteristics of joints, tendons and muscles conditioned by the action of various external forces, and it has been proven that explosive strength, balance and agility are positively correlated with competitive results in alpine skiing (Suchomel et al., 2019; Murovec, 2006). The development of all motor abilities can be influenced most during childhood (Kostelić, 2005; Bompa & Buzzichelli, 2019). The identification of essential characteristics and abilities for success in alpine skiing is important because such data enable a better diagnosis of the current state of the alpine skier (Hydren et al., 2013).

Contemporary alpine skiing research by numerous authors (Gilgien et al., 2013; Krautgasser et al., 2009; Cigrovski et al., 2008) consistently demonstrates that competitive performance requires not only exceptional technical proficiency but also a comprehensive physiological profile featuring well-developed aerobic and anaerobic capacities alongside specific motor abilities including strength, explosiveness, agility, balance, flexibility and coordination. Recent research further confirms these findings. According to Ellis & Sparovec (2009), Prestes et al. (2019), and Watson (2017), coordination, explosive strength, agility, and flexibility play a crucial role in achieving success in alpine skiing. For top results in this sport, perfecting technique alone is insufficient; it's essential to develop aerobic and anaerobic capacities to a high level, as demonstrated by studies from multiple authors (Latella et al., 2020; Suchomel et al., 2019). Contemporary research (Burtscher et al., 2009; Stöggl et al., 2010) emphasizes that adequate physical conditioning not only enhances athletic performance but significantly reduces the risk of injuries that skiers are exposed to during competitions.

Stöggl et al. (2013) state that energy needs are equal to ~80-90% VO2max during skiing, while Sekulić et al. (2006) speak of energy needs of 120% VO2max, in which the oxygen debt of anaerobic sources was calculated by measuring the concentration of lactate in the blood after skiing which is confirmed in research conducted by Krautgasser et al. (2009). Research by multiple investigators (Sekulić & Rausavljević, 2006) demonstrates significant physiological adaptations occurring during a typical week-long skiing program. Following six days of skiing activity, the cardiovascular system

shows measurable adaptations, with heart rate responses becoming more efficient in relation to changing skiing intensities. These adaptations coincide with altered metabolic responses, including increased energy expenditure and elevated lactic acid production during equivalent workloads. Repeated eccentric contractions, such as repeated downhill turns, lead to increased muscle damage, resulting in increased blood creatine kinase levels, pain, and loss of strength, which peak three days after exercise consisting of isometric contractions (Mackey et al., 2008).

Comprehensive research into the physiological demands of alpine skiing reveals significant muscular and metabolic stress markers. Recent investigations by Sekulić & Rausavljević (2006) documented substantial increases in creatine kinase levels—a key marker of muscle damage—with concentrations rising 93% above baseline after just one day of skiing. Similarly, Krautgasser et al. (2009) observed a 42% elevation in blood creatine kinase levels following only three hours of recreational skiing. These findings align with contemporary research on muscle glycogen utilization during alpine skiing activities. Watson (2017) reported approximately 50% depletion of intramuscular glycogen stores after a single day of skiing, with depletion patterns varying based on skiing intensity and technical proficiency. Recent work by Hydren et al. (2013) suggests these physiological responses represent significant training stimuli that can be harnessed for performance enhancement when properly managed through periodized training approaches. It should be noted that numerous studies have shown that anthropometric characteristics, especially height and weight, are limiting factors in achieving top results in skiing (Cigrovski et al., 2008; Brezavšček, 2010; Williams et al., 2017). Research has also been conducted (Murovec, 2006) towards learning alpine skiing techniques and faster progress in alpine skiing school, in which it is recommended that before going to the ski slopes, that is, before learning alpine skiing, use rollers as a sports and recreational preparation for learning alpine skiing. Comparative analyses of the dynamic characteristics between alpine skiing slalom and its inline skating counterparts remain relatively limited in the scientific literature. Key investigations in this area include the work of Roman et al. (2009), who examined transfer effects between inline training and on-snow performance, and Bandalo (2009), who conducted detailed electromyographic comparisons of muscle activation patterns between the two disciplines. Murovec (2006) believes that the first steps on snow are learned on extremely short skis of around 90 centimeters in length, then one moves on to longer skis of 125 centimeters, and at the end of the training process, skis selected according to the morphological characteristics of the skiers themselves are used, thus omitting the elements

of snowplowing ski technique. This is supported by research that states that the long-term position in the snowplowing position for the skier is a burden on the joints and muscles of the lower extremities, and that it is not possible to dynamically master the ski track using this skiing technique (Murovec, 2006; Del Pulp et al., 2002; Matković et al., 2004), which indicates the need to implement a program to raise the level of physical preparedness of future skiers trainees.

Recreational skiing can be enjoyed by the whole family, regardless of age, making it one of the most popular forms of family recreation. Koehle et al. state that as early as 2002, there were around 200 million recreational skiers worldwide, while Horterer (2005) states a slightly lower figure of around 82 million registered recreational alpine skiers. Travel agencies mostly base their offer on a seven-day winter holiday, and ski resorts themselves mostly organize their offer on a seven-day period within which alpine skiing school usually lasts six days. During these six days, students learn the basic elements of technique, which they can independently apply while mastering the ski terrain (Matković et al., 2004). Contemporary pedagogical research examining the acquisition of alpine skiing skills highlights the effectiveness of concentrated six to seven-day learning periods (Sekulić & Rausavljević, 2006; Cigrovski et al., 2010). Beyond recreational enjoyment, alpine skiing delivers substantial health benefits by developing a comprehensive range of motor abilities including balance, agility, coordination, strength, flexibility, and endurance. This aligns with current public health perspectives emphasizing holistic fitness development, as documented by Britton et al. (2020). The growing focus on physical fitness has established muscle strength development as a cornerstone in disease prevention, functional capacity enhancement, and quality of life improvement (Schoenfeld et al., 2021; Prestes et al., 2019). In contemporary exercise science, structured group fitness programs represent one of the most accessible and effective approaches to sports recreation. These systematically repeated exercise formats produce significant positive adaptations in physiological functioning and body composition metrics (Rodrigues et al., 2021), making them valuable components in both general fitness programming and sport-specific training for alpine skiing. Health fitness is multidimensional and includes components - cardiorespiratory endurance, muscular strength, muscular endurance, flexibility and body composition (Britton et al., 2020), while motor fitness includes abilities important for performance in certain sports that do not directly affect health balance, reaction speed, strength and coordination.

Research objectives

The primary objective of this investigation was to determine whether a structured group fitness program could effectively enhance various dimensions of physical fitness relevant to alpine skiing performance. Additionally, the study sought to establish evidence-based protocols that could be adapted for older adult populations engaging in recreational alpine skiing, addressing the specific physiological demands and injury prevention concerns unique to this demographic.

Research methodology

Type of research

The type of this research was research-observational, using motor tests to evaluate the effectiveness of a group fitness program in preparation for skiing lessons. By conducting standardized tests, valid data was obtained, and we got information about the possibilities of raising the physical preparation of students. The experimental aspects of this work facilitated the identification of ways to improve the physical preparedness of students, including the need for teacher training and the adjustment of classes designed to increase their physical preparedness, according to the principles of group fitness programs. That would lead to preventing injuries and more efficient implementation of practical skiing lessons at the university level.

Research group

The research was conducted on 14 male participants aged 20-21, second-year students at the Faculty of Physical Education and Sport in Banja Luka. The subjects, selected randomly, were divided into two groups of 7 subjects each, which comprised the control and experimental groups. The subjects in the control group did not participate in the 12-week group fitness program with an exercise interval of 4 training sessions per week, which the subjects in the experimental group were subjected to. The subjects were in optimal health status without the presence of diseases and injuries of the locomotor apparatus and were not involved in the teaching process or in organized sports or recreational exercises outside the experiment.

Experimental program

The present investigation utilized Stoppani's (2015) 12-week periodized training program, chosen based on selection criteria that corresponded with the established research aims (Retrieved May 29, 2025, from https://studylib.net/doc/6975063/12-week-beginning-weight-training-program). This program was specifically selected for its unique combination of comprehensive physiological stimulus and practical implementation efficiency, which allowed for optimal assessment of multidimensional fitness adaptations across our diverse measurement variables. Additionally, the program's established popularity and documented success rates in various populations provided a methodologically sound foundation for investigating training-induced adaptations in our target demographic. This program was chosen for its established theoretical foundation in periodization and microcycles, building on principles established by Bompa and Buzzichelli (2019) regarding systematic training progression. The program's comprehensive approach to developing multiple fitness components (strength, hypertrophy, and fat reduction) follows evidence-based recommendations by Schoenfeld et al. (2021) for concurrent adaptations to resistance training. The systematic progression through clearly defined phases reflects linear periodization models that have demonstrated efficacy in improving strength and body composition in both trained and untrained individuals (Harries et al., 2015; Williams et al., 2017). The program's structure allowed for efficient group implementation using a station-based format where all subjects could exercise simultaneously with appropriate equipment. The program consists of four weekly workouts targeting different muscle groups: (1) chest, triceps, and calves; (2) back, biceps, and abdominals; (3) shoulders, trapezius, and calves; and (4) legs and core. Each four-week phase followed a specific repetition scheme with progressive overload: week 1 (12-15 repetitions), week 2 (9-11 repetitions with increased weight), week 3 (6-8 repetitions with further weight increase), and week 4 (3-5 repetitions with maximum weight). This repetition range variation aligns with Ratamess et al.'s (2009) recommendations in the ACSM position stand on resistance training for healthy adults. The systematic progression was repeated across three phases, with each subsequent phase implementing heavier weights (5-20 pounds heavier) than the previous phase, consistent with progressive overload principles described by Haff & Triplett (2016). This structured approach facilitated standardized implementation and reliable assessment of adaptations across our comprehensive battery of morphological, functional, and motor ability assessments.

Variables

The values of the variables of anthropological characteristics and the results of certain motor abilities were determined for the subjects of both groups before and after the implementation of the fitness program. The following variables and tests were used to assess the level of physical fitness:

1. Variables of morphological characteristics:
   - body composition – fat% (percentage of fat tissue), tbw (amount of water in the body), fat% left leg (percentage of fat tissue in the left leg), fat% right leg (percentage of fat tissue in the right leg), fat% trunk (percentage of fat tissue in the trunk) which were assessed using a Body composition analyzer (TANITA BMN III).
2. Variables of functional abilities:
   - VO_{2max} (measured using an indirect method using the beep test), harvard test, bmp (basal metabolism)
3. Variables of motor abilities:
   - Explosive strength was assessed using the Kistler platform (according to Čanaki et al., 2006): SJ-squat jump (jump height)(SJH) and CMJ-standing jump (jump height, rebound time)(CMJT i CMJH) (according to the Brezavšček protocol, 2010), long jump from a standing position (MFESDM), (Metikoš et al., 1989),
   - starting reaction, starting acceleration and speed were assessed using test results: 10-meter run(MFE10V), 20-meter run (MFE20V), 100-meter run(MFE100V) (Metikoš et al., 1989),
   - agility was assessed using test results: lateral agility with a hop step(MAGKUS), t-test(TT), envelope test(MAGTUP), figure eight with bending (MAGOSS), agility on the ground(MAGONT), backward polygon (MREPOL) (Metikoš et al., 1989),
   - static power was assessed using tests: half-squat endurance, wall squat test (left and right leg)(WST L/R), back extension endurance (HYPEXT), (Metikoš et al., 1989),
   - repetitive strength was assessed by tests: torso lift on a bench (MRSPTR), chin-up (MRAZGP), push-up(PU), (Metikoš et al., 1989),
   - balance was assessed by tests performed on a wooden platform: balance position by standing on a balance bench on one leg lengthwise with eyes open (MBAU10), balance position by standing on a balance bench on one leg lengthwise with eyes closed (MBAU1Z), flamingo test (FLAMIN) (Metikoš et al., 1989).

Data analisyes

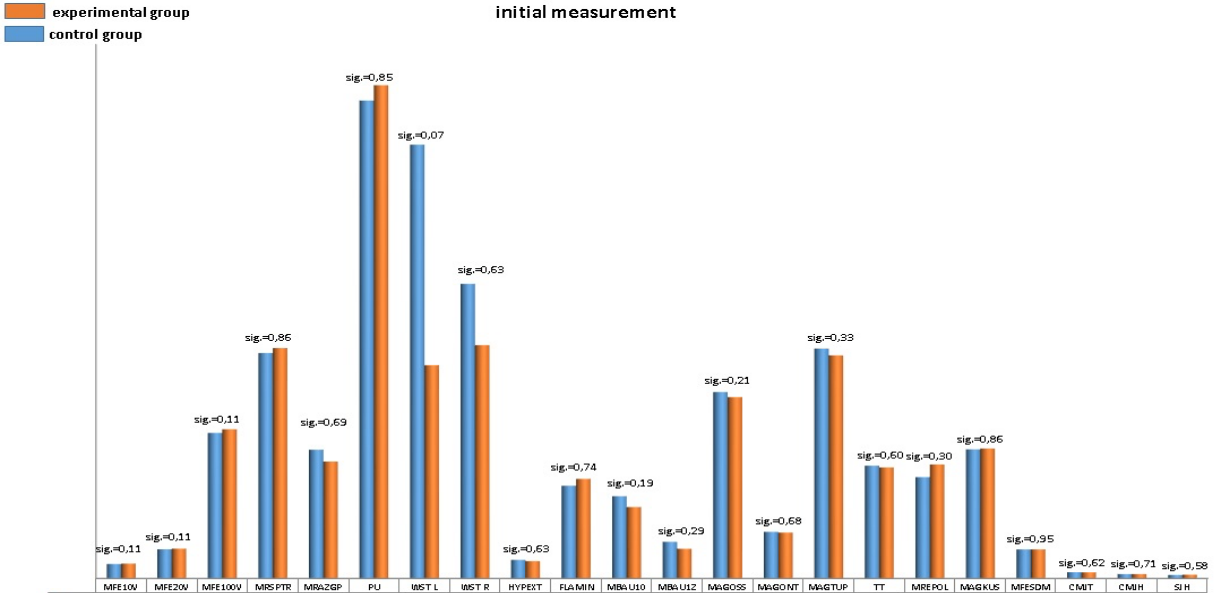
To ensure methodological rigor and draw statistically valid conclusions, this study employed a comprehensive analytical approach featuring both descriptive and inferential statistical procedures. Descriptive statistics included calculation of central tendency (arithmetic mean) and dispersion parameters (standard deviation), while distribution normality was verified using the Kolmogorov-Smirnov test. For comparative analyses, the investigation utilized independent samples t-tests to evaluate between-group differences and paired-sample t-tests to assess within-group changes across measurement time points. Effect size calculations (Cohen's d) were implemented to quantify the magnitude of observed differences, providing context beyond mere statistical significance. Additionally, discriminant canonical analysis was employed to identify which specific physical fitness variables contributed most substantially to differentiating between experimental conditions. All statistical procedures were executed using IBM SPSS Statistics (version 27.0, IBM Corp., Armonk, NY), following contemporary analytical recommendations by Prestes et al. (2019) for exercise intervention research.

Ethical issues

As the research involved human participants, ethical approval was obtained in accordance with the principles outlined in the Declaration of Helsinki. All participants voluntarily provided informed consent and were made aware of the right to withdraw from the experiment at any time. The study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, University of Banja Luka, Bosnia and Herzegovina.

Results with discussion

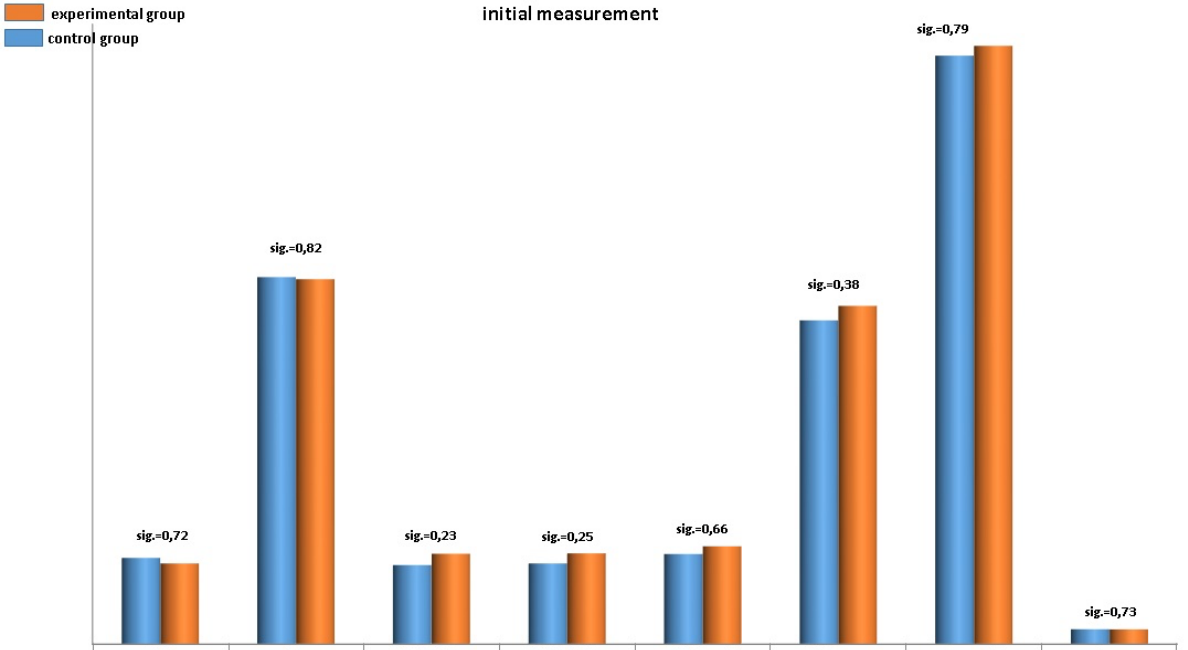
Graph 1 - Descriptive parameters, significance values of the independent T-test of the initial measurement of motor ability, control and experimental groups



	MFE10V	MFE20V	MFE100V	MRSPTR	MRAZGP	PU	WST L	WST R	HYPEXT	FLAMIN	MBAU10	MBAU1Z	MAGOSS	MAGONT	MAGTUP	TT	MREPOL	MAGKUS	MFESDM	CMJT	CMJH	SJH
	1.22	2.45	12.26	19.00	10.85	40.28	36.56	24.83	1.56	7.81	6.93	3.08	15.71	3.93	19.37	9.5	8.54	10.88	2.44	0.52	0.37	0.29
	1.25	2.51	12.57	19.42	9.85	41.57	17.97	19.66	1.46	8.39	6.02	2.50	15.28	3.86	18.8	9.35	9.61	10.95	2.44	0.51	0.36	0.31

Legend: MFE10V-10 meter run, MFE20V-20 meter run, MFE100V-100 meter run, MRSPTR-body lift on bench, MRAZGP-pull-ups on a beam, PU-push-ups, WSTL-semi-squat endurance wall squat test left leg, WSTR-semi-squat endurance wall squat test right leg, HZPEXT-back extension endurance, FLAMIN-flamingo test, MBAU10-balance position by standing on a balance bench on one leg lengthwise with eyes open, MBAU1Z-balance position by standing on a balance bench on one leg lengthwise with eyes closed, MAGOSS-figure eight with bending, MAGONT-agility on the ground, MAGTUP-envelope test, TT-T test, MREPOL-backward polygon, MAGKUS-hop step, MFESDM-long jump from a standing position, CMJT-jump from a standing position jump time, CMJH-jump from a standing position jump height, SJH -jump from a squat jump height, sig.-significance

Graph 2 - Descriptive parameters, significance values of independent T-test of initial measurement control and experimental group's morphology and functional abilities

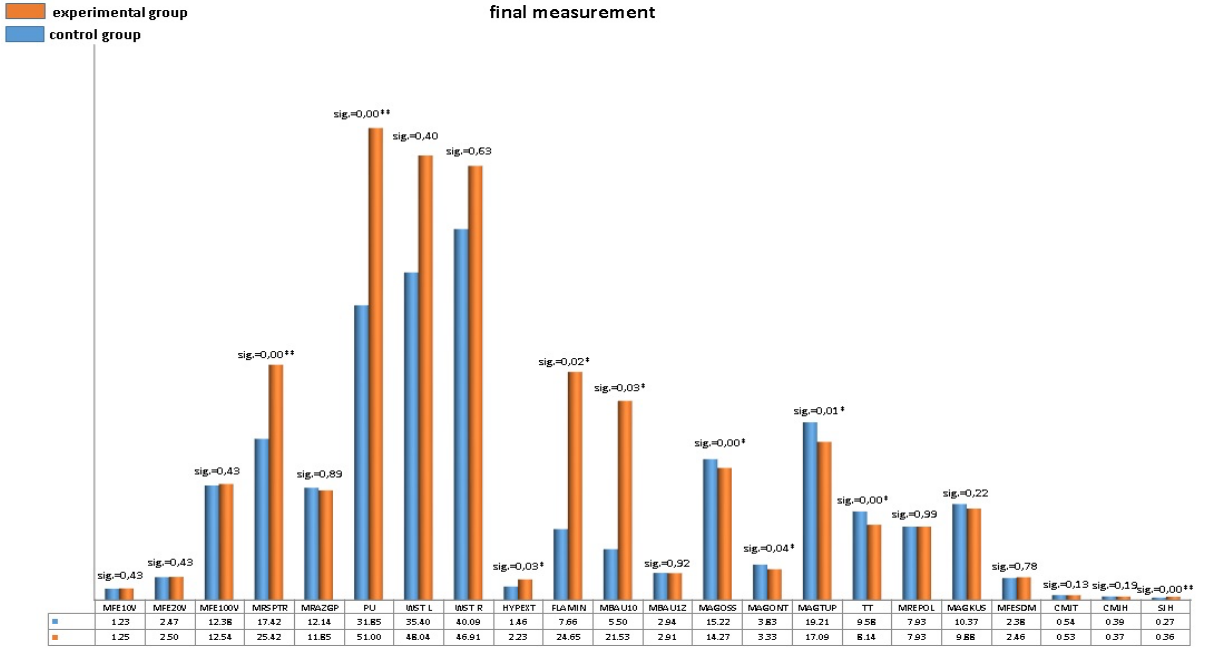


	Fet%	Tbw	Fet% left leg	Fet% right leg	Fet% trunk	VO2max	harvard	bmr
■	12.51	53.27	11.47	11.71	13.07	47.00	85.42	2.17
■	11.72	52.97	13.11	13.17	14.21	49.10	86.85	2.15

Legend: Fet%-percentage of fatty tissue in the body, Tbw-total water in the body, Fet% left leg -percentage of fatty tissue in the left leg, Fet% right leg -percentage of fatty tissue in the trunk, Fat% trunk-percentage of fat tissue in the trunk, VO_{2max} *- maximum oxygen consumption (beep test), harvard-harvard step test, bmr-basal metabolism, sig.-significance*

Initial assessment of morphological characteristics and motor abilities, illustrated in Graphs 1-2, confirmed no statistically significant between-group differences prior to intervention ($p > 0.05$). This homogeneity at baseline validates the sampling methodology and experimental design, effectively controlling for potential confounding variables that might otherwise influence post-intervention outcomes. At the final measurement, certain differences were observed between the experimental and control groups in Graphs 3-4. Differences were observed in the variables that analyzed *morphological characteristics*: Fet%, Tbw and Fet%trunk; *functional abilities*: VO_{2max} and Bmr; *explosive strength of the jumping type*: SJH; *coordination of the agility type*: MAGOSS, MAGONT, MAGTUP and TT; *static strength*: ekstenleđa; *repetitive strength*: MRSPTR and PU and *balance*: FLAMIN and MBAU10. Based on the value of the difference effect (ES) (Cohen, 1988), it can be concluded that all the differences are above the large effect value (above 0.14), which, expressed in percentages, means that in terms of *morphological characteristics*: 48% of the differences in the variable Fet%, 43% in the variable Tbw and 29% in the variable Fet%trup; *functional abilities*: 40% difference in the variable $VO_{2max}$and 73% in the variable Bmr; *explosive strength of the jumping type*: 60% of the difference in the variable SJH; *coordination of the type of agility*: 80% difference in the variable MAGOSS, 49% in the variable MAGONT, 60% in the variable MAGTUP and 87% in the variable TT; *static strength*: 71% of the difference in the HYPEXT variable; *repetitive strength*: 73% of the difference in the MRSPTR variable and 88% in the PU variable and *balance*: 57% of the difference in the FLAMIN variable and 56% can be explained by the influence of the training process.

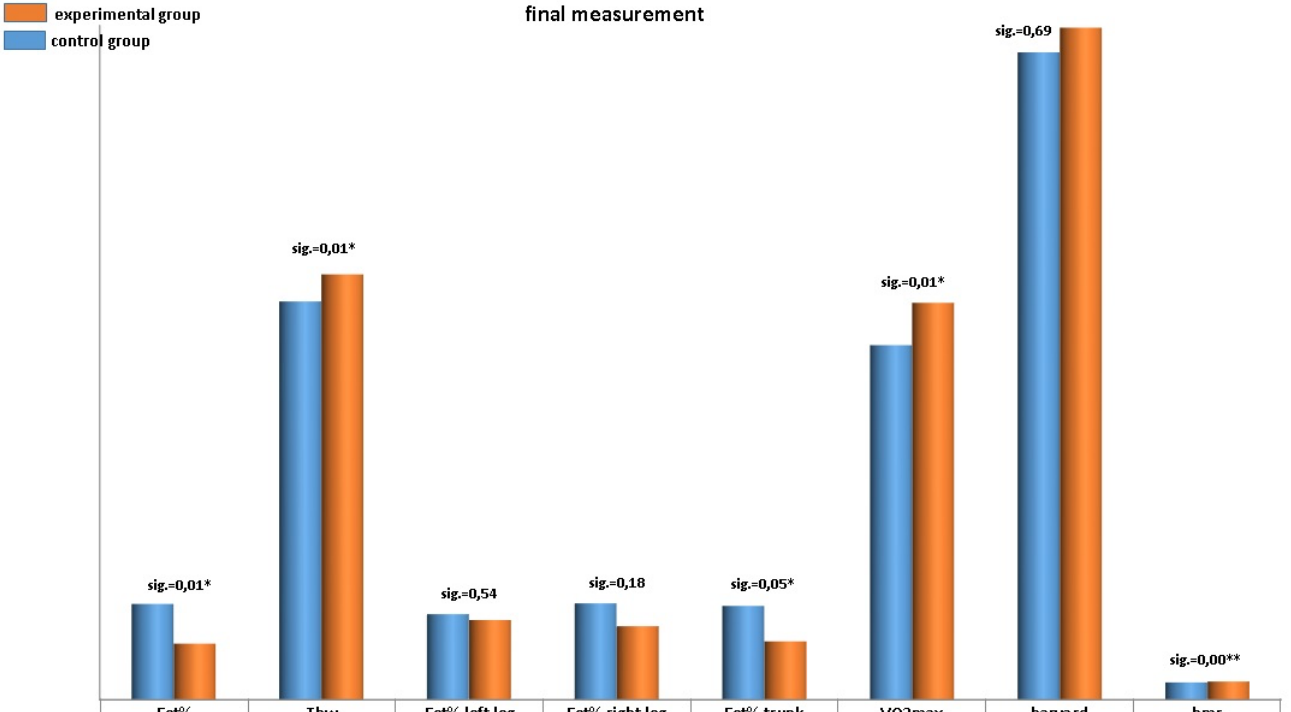
Graph 3 - Results of descriptive statistics and significance values of the independent T-test of the final measurement of motor ability, control and experimental groups



	MFE10V	MFE20V	MFE100V	MRSPTR	MRAZGP	PU	WSTL	WSTR	HYPEXT	FLAMIN	MBAU10	MBAU1Z	MAGOSS	MAGONT	MAGTUP	TT	MREPOL	MAGKUS	MFESDM	CMJT	CMJH	SJH
	1.23	2.47	12.38	17.42	12.14	31.85	35.40	40.09	1.46	7.66	5.50	2.94	15.22	3.83	19.21	9.58	7.93	10.37	2.38	0.54	0.39	0.27
	1.25	2.50	12.54	25.42	11.85	51.00	48.04	46.91	2.23	24.65	21.53	2.91	14.27	3.33	17.09	8.14	7.93	9.88	2.46	0.53	0.37	0.36

Legend:MFE10V-10 meter run, MFE20V-20 meter run, MFE100V-100 meter run, MRSPTR-body lift on bench, MRAZGP-pull-ups on a beam, PU-push-ups, WSTL-semi-squat endurance wall squat test left leg, WSTR-semi-squat endurance wall squat test right leg, HZPEXT-back extension endurance, FLAMIN-flamingo test, MBAU10-balance position by standing on a balance bench on one leg lengthwise with eyes open, MBAU1Z-balance position by standing on a balance bench on one leg lengthwise with eyes closed, MAGOSS-figure eight with bending, MAGONT-agility on the ground, MAGTUP-envelope test, TT-T test, MREPOL-backward polygon, MAGKUS-hop step, MFESDM-long jump from a standing position, CMJT-jump from a standing position jump time, CMJH-jump from a standing position jump height, SJH -jump from a squat jump height, sig.-significance

Graph 4 - Results of descriptive statistics and significance values of the independent T-test of the final measurement of control and experimental group's morphology and functional abilities

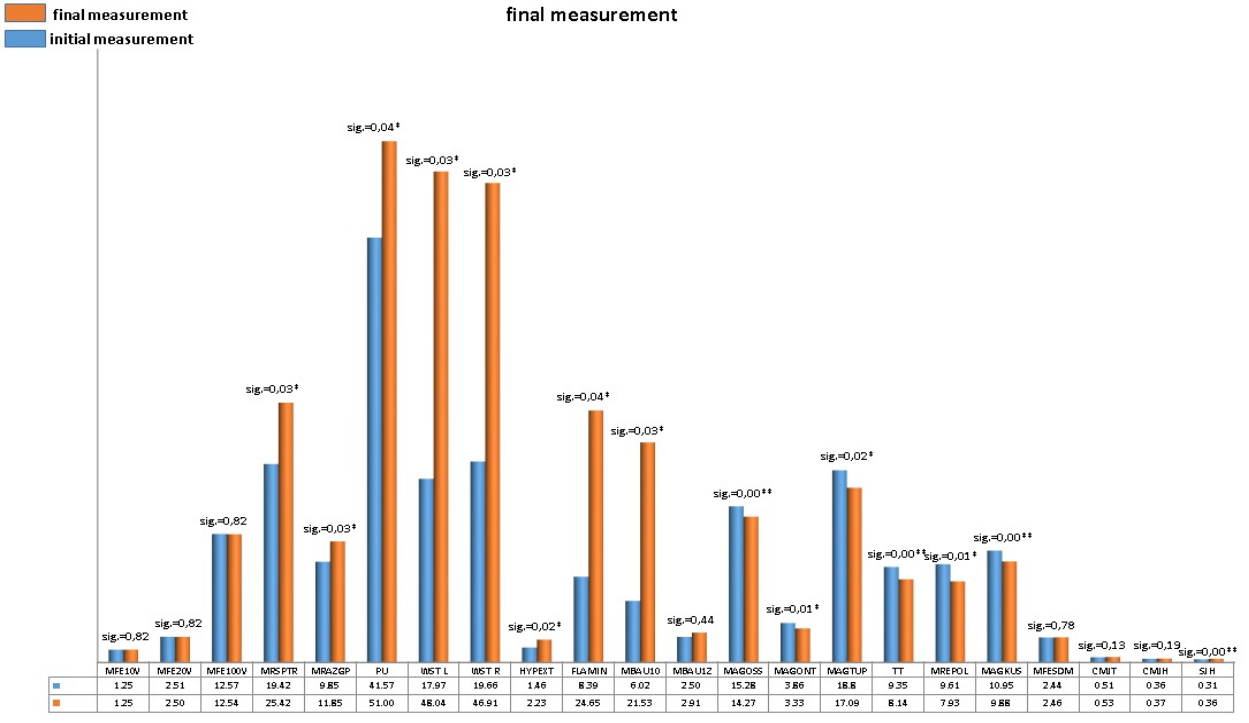


	Fet%	Tbw	Fet% left leg	Fet% right leg	Fet% trunk	VO2max	harvard	bmr
■	12.77	53.15	11.41	12.85	12.52	47.32	86.42	2.31
■	7.48	56.77	10.64	9.81	7.78	52.97	89.71	2.43

Legend: Fet%-percentage of fatty tissue in the body, Tbw-total water in the body, Fet% left leg -percentage of fatty tissue in the left leg, Fet% right leg -percentage of fatty tissue in the trunk, Fat% trunk-percentage of fat tissue in the trunk, VO_{2max} - maximum oxygen consumption (beep test), harvard-harvard step test, bmr-basal metabolism, sig.-significance

Analysis of pre-intervention and post-intervention measurements in the experimental group, displayed in Graphs 5-6, revealed significant improvements across multiple fitness parameters following the twelve-week training protocol. A statistically significant difference is visible and was observed in the variables that analyzed the *morphological characteristics* of the subjects: Fet%, Tbw, Fet%left leg,Fet%right leg and Fet%trunk; *functional abilities*: VO_{2max} and Bmr; *explosive strength of the jumping type*: SJH; *coordination of the agility type*: MAGOSS, MAGONT, MAGTUP, TT, MREPOL and MAGKUS; *static strength*: WST L, WST D and HYPEXT; *repetitive strength*: MRSPTR, MRAZGP and PU and *balance*: FLAMIN and MBAU10. Based on the value of the effect of difference (ES) (Cohen, 1988), it can be concluded that the differences are above the value of the large effect (above 0.14), which, expressed in percentages, means that in terms of *morphological characteristics*: 82% of the difference in the variable Fet%, 62% in the variable Tbw and 53% in the variables Fet% left leg, Fet%right leg and Fet%trunkcan be explained by the influence of the training process. The same is the case with other tests that analyzed functional abilities: 60% of the difference in the VO_{2max} variable and 78% in the Bmr variable; *explosive strength of the jumping type*: 58% of the difference in the variable SJH; *agility type coordination*: 66% difference in the variable MAGOSS, 51% in the variable MAGONT, 41% in the variable MAGTUP, 65% in the variable TT, 49% in the variable MREPOL and 75% in the variable MAGKUS; *static strength*: 39% difference in WST L variable, 51% in WST Dvariable and 42% in HYPEXT variable; *repetitive strength*: 39% difference in the variables MRSPTR and MRAZGP, and 34% in the variable PU and *balance*: 36% of the difference in the FLAMIN and MBAU10 variables can be explained by the influence of the training process. Post-intervention analysis in the experimental group revealed significant improvements across several morphological variables: Fet% decreased by 36.17%, the variable Fet% left leg decreased by 18.84%, the variable Fet%right leg decreased by 25.51% and the variable Fet%trunk decreased by 45.25%, while the variable Tbw increased by 7.17%; functional abilities: VO_{2max} increased by 12.70%, and the variable Bmr also increased by 11.74%; *explosive strength of the jumping type*: SJH increased by 16.12%; *agility type coordination*: decreased by 6.60% for the MAGOSS variable, 13.73% for the MAGONT variable, 9.09% for the MAGTUP variable, 12.94% for the TT variable, 17.48% for the MREPOL variable and 9.77% for the MAGKUSvariable and *repetitive strength*: increased by 30.89% for the MRSPTR variable, 20.30% for the MRAZGP variable and 22.68% for the PU variable.

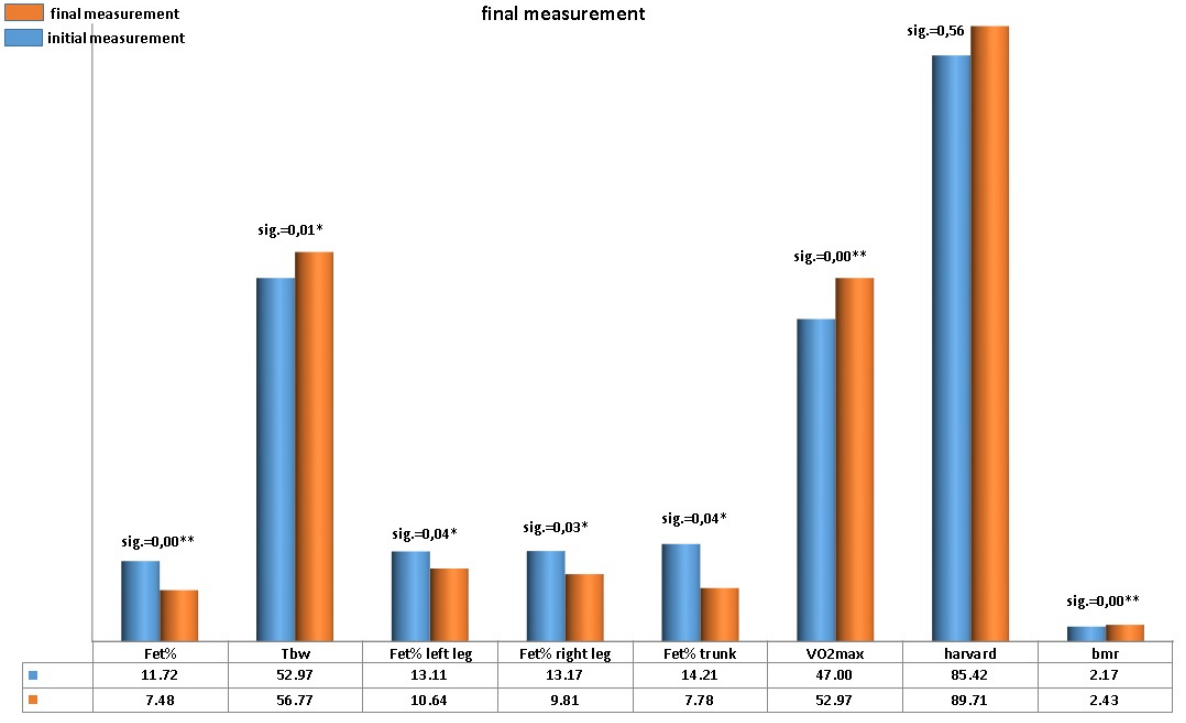
Graph 5 - Results of descriptive statistics and significance of the dependent t-test in the experimental group on the initial and final measurement of motor ability



	MFE10V	MFE20V	MFE100V	MRSPTR	MRAZGP	PU	WST L	WST R	HYPEXT	FLAMIN	MBAU10	MBAU12	MAGOSS	MAGONT	MAGTUP	TT	MREPOL	MAGKUS	MFESDM	CMJT	CMJH	SJH
	1.25	2.51	12.57	19.42	9.85	41.57	17.97	19.66	1.46	8.39	6.02	2.50	15.28	3.86	18.8	9.35	9.61	10.95	2.44	0.51	0.36	0.31
	1.25	2.50	12.54	25.42	11.85	51.00	48.04	46.91	2.23	24.65	21.53	2.91	14.27	3.33	17.09	8.14	7.93	9.88	2.46	0.53	0.37	0.36

Legend: MFE10V-10 meter run, MFE20V-20 meter run, MFE100V-100 meter run, MRSPTR-body lift on bench, MRAZGP-pull-ups on a beam, PU-push-ups, WSTL-semi-squat endurance wall squat test left leg, WSTR-semi-squat endurance wall squat test right leg, HZPEXT-back extension endurance, FLAMIN-flamingo test, MBAU10-balance position by standing on a balance bench on one leg lengthwise with eyes open, MBAU1Z-balance position by standing on a balance bench on one leg lengthwise with eyes closed, MAGOSS-figure eight with bending, MAGONT-agility on the ground, MAGTUP-envelope test, TT-T test, MREPOL-backward polygon, MAGKUS-hop step, MFESDM-long jump from a standing position, CMJT-jump from a standing position jump time, CMJH-jump from a standing position jump height, SJH -jump from a squat jump height, sig.-significance

Graph 6 - Results of descriptive statistics and significance of dependent t-test in the experimental group at the initial and final measurements of morphology and functional ability



Legend: Fet%-percentage of fatty tissue in the body, Tbw-total water in the body, Fet% left leg -percentage of fatty tissue in the left leg, Fet% right leg -percentage of fatty tissue in the trunk, Fat% trunk-percentage of fat tissue in the trunk, VO_{2max} *- maximum oxygen consumption (beep test), harvard-harvard step test, bmr-basal metabolism, sig.-significance*

Table 2 - Significance of the isolated discriminative function of morphological characteristics and motor abilities in the experimental group

Function	Eigenvalue	Canoni. Corr.	Wilks' Lambda	Chi-square	Sig.	variable	Function 1
1	10,46	0,95	0,08	23,17	0,00	Fet%	0,41
						Fet% right leg	0,25
						Fat% trunk	0,22
						Tbw	-0,22
						Fet% left leg	0,19
1	3,68	0,88	0,21	16,21	0,00	bmr	0,77
						VO_{2max}	0,71
						harvard	0,08
1	10,94	0,95	0,08	22,32	0,00	MAGOSS	0,53
						MAGONT	0,39
						MAGKUS	0,37
						TT	0,35
						MAGTUP	0,28
						MREPOL	0,26
1	1,04	0,71	0,49	7,49	0,05	MRSPTR	0,85
						PU	0,70
						MRAZGP	0,33

Legend: Fet%-percentage of fatty tissue in the body, Tbw-total water in the body, Fet% left leg -percentage of fatty tissue in the left leg, Fet% right leg -percentage of fatty tissue in the trunk, Fat% trunk-percentage of fat tissue in the trunk,VO_{2max} - maximum oxygen consumption (beep test), harvard-harvard step test, bmr-basal metabolism,MAGOSS-figure eight with bending, MAGONT-agility on the ground, MAGTUP-envelope test, TT-T test, MREPOL-backward polygon,MAGKUS-hop step,MRSPTR-body lift on bench, MRAZGP-pull-ups on a beam, PU-push-ups

Following confirmation of significant changes in morphological characteristics and motor abilities after the twelve-week intervention, discriminative canonical analysis was conducted to identify variables most responsive to the training stimulus. Table 2 presents the statistically significant discriminative functions of high intensity, revealing that the program produced greatest adaptations in specific morphological characteristics, functional capacities, agility-type coordination, and repetitive strength parameters. If the control and experimental groups are compared, differences are observed in the variables at the final measurement compared to the initial one:

- body composition-Fet%, Tbw; Fet%trunk, everything is better in the experimental group.
- functional abilities - VO2max and bmr are all better in the experimental group

- explosive strength of the jumping type: SJH, better in the experimental group
- speed-type explosive power has no differences between groups at the final measurement,
- agility type coordination: difference in all variables - MAGOSS, MAGONT, MAGTUP, TT (they are all better in the experimental group)
- static strength: HYPEXT, better in the experimental group
- repetitive strength - lifting the torso on the bench and push-ups, all are better in the experimental group
- balance-FLAMIN and MBAU10, all are better in the experimental group.

The results of the application of a group fitness program for strength development indicate significant adaptations in muscle strength, which is consistent with contemporary research on progressive resistance training. Recent studies have emphasized the importance of periodized training programs that incorporate progressive overload principles to optimize strength and performance adaptations (Prestes et al., 2009; Latella et al., 2020). Current research in resistance training has evolved to emphasize not only load progression but also the importance of exercise selection, movement patterns, and recovery protocols in maximizing training adaptations. From an educational perspective, contemporary findings highlight the importance of individualized approaches within group training environments, as individual responses to identical training stimuli can vary significantly due to genetic factors, training history, and recovery capacity (Pickering & Kiely, 2019). This presents valuable implications for physical education settings, where educators need to balance standardized programming with individualized modifications to optimize student development. Many available studies in the field of alpine skiing have shown the connection of certain motor abilities and morphological characteristics with success in competition. Recent research by Gilgien et al. (2013) has utilized advanced wearable technology to quantify the specific physiological demands of modern alpine skiing, revealing that contemporary competitive skiing requires unique combinations of eccentric and concentric strength, emphasizing the need for specialized training approaches that differ from traditional strength training paradigms. Stöggl et al. (2021) demonstrated that explosive strength development in alpine skiers must be complemented by sport-specific balance and proprioceptive training to transfer effectively to on-snow performance. This supports previous findings while adding contemporary context regarding training specificity and

skill transfer in winter sports education. Importantly, new evidence suggests that the relationship between physical fitness parameters and skiing performance is mediated by technical proficiency, emphasizing the need for integrated technical and physical development programs. In educational settings, Hydren et al. (2013), found that collegiate ski programs implementing comprehensive strength and conditioning programs that emphasize both general athletic development and sport-specific movement patterns show superior outcomes in both injury prevention and performance metrics compared to more traditional approaches. This has significant implications for physical education curriculums seeking to incorporate winter sports preparation. The use of group fitness programs provides additional benefits compared to individual training, including increased motivation and social support among participants. Recent meta-analyses have demonstrated that group-based exercise interventions produce superior adherence rates and psychological outcomes compared to individual training, particularly in educational environments (Rodrigues et al., 2021). This social component of exercise has gained increased recognition in contemporary exercise psychology, with evidence suggesting that perceived social connection during physical activity strongly predicts long-term engagement and intrinsic motivation development (Williams et al., 2016). From a pedagogical perspective, modern approaches to physical education emphasize the development of physical literacy through varied movement experiences rather than isolated physical capacities (Durden-Myers et al., 2021). Contemporary physical education frameworks suggest that activities like alpine skiing present valuable opportunities for developing integrated physical competencies that transfer to multiple domains of physical activity. These findings suggest that physical educators should emphasize the broader educational value of complex movement activities like skiing, rather than focusing exclusively on specific physical adaptations. In conclusion, the findings of this study align with contemporary research while offering valuable insights into the educational applications of periodized group fitness programs. Current evidence strongly supports the effectiveness of structured progressive training for developing physical capacities relevant to alpine skiing, while also highlighting the importance of considering the broader educational context, including motivation, social dynamics, and long-term physical literacy development.

Limitations of the research

Despite the promising results, there are certain limitations of this research. Variable individual characteristics, such as previous training

experience, nutritional habits, and recovery, can affect strength adaptations, requiring further individualization of programs. Furthermore, the number of participants in the study and the duration of the research could have limited the generalization of the results to a wider population, and further research with larger samples and long-term follow-up is recommended. Based on the results obtained, future research should focus on expanding the sample of participants to increase the statistical power and general validity of the results, on examining the influence of additional variables such as specific nutrition and additional forms of recovery, and on comparative studies between group and individual training programs to better understand the advantages and disadvantages of each approach.

Conclusion

It was found that a group fitness program based on the concept of periodization and microcycles, and designed with the aim of increasing strength, increasing muscle mass and reducing body fat, can have a positive effect in raising the level of physical fitness. This research pointed to the possible application of group fitness programs to raise the level of abilities essential for a particular sport. It was also found that the student population can be adequately prepared for practical skiing lessons, which can avoid the occurrence and injury and ensure better quality of teaching.

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