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Original Article

Fitness level testing in U16 performance alpine skiing athletes

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Abstract:
Problem Statement. These physical fitness attributes include the components of agility, balance, body composition, cardiovascular fitness, coordination, flexibility, muscular endurance, muscular strength, power, reaction time, and speed (Caspersen et.all., 1985; Corbin, et.all, 2000). Approach. The study includes a number of 10 athletes, aged 16, boys, who represent the members of the alpine skiing section, within a sports club, under private law. To assess the physical condition of U16-year-old skiers, a pre-test (at the beginning of October) and a post-test (at the end of November) were performed, and four tests were selected and applied: "Sit & reach"; Maximum "Push Up in 60 seconds"; "Penta Jump"; "Single Leg Squat"), part of - "Fitness Testing Protocol Ski, Australia", 2005**. Purpose.** The aim of the study is to test the fitness level, in a group of U16 years old, boys, following the implementation of an 8-week physical training program, which targets the following components: (flexibility, strength and muscular endurance, in the upper limbs, explosive force / power in the lower limbs), which can provide a solid basis for preparation for performance. ***Results.*** Thus, following the application of the four tests, presented in the research, significant values are recorded at the group level, between the two moments of testing, for the following significance thresholds: in the "Sit & Reach" test, there is a statistically significant difference in ($p < 0.982$ and $t = 3.551$); in the "Maximum Push up in 60 seconds" test, there is a statistically significant difference at ($p < 0.945$ and $t = 2.80$); in the "Penta jumps" test for measuring explosive force and power, there is a statistically significant difference at ($p < 0.979$ and $t = 3.39$), and in "Single leg Squad" there is a statistically significant difference at ($p < 0.963$ and $t = 3.78$). **Conclusions.** We can say that, following the application of an 8-week physical training program, to improve physical condition, in a group of U16-year-old skiers, significant differences can be observed between the two moments of testing, both in the group and in the individual progress of the athletes.
Key Words: **fitness, performance, alpine skiing.**

Introduction

Physical fitness can be defined as a set of attributes that an individual has or achieves, relating to their ability to perform daily tasks (Caspersen, et. all., 1985). Alpine ski racing demands a multitude of technical skills and excellent physical abilities, but there is relatiely little current published sport scientific data regarding conditioning characteristics of a successful alpine ski racer.

Strength, power, speed muscular endurance, the energy systems including cardiovascular endurance, agility, flexibility, and reaction time/ movement time/ response time are the most important physical factors in the development of an athlete. All these factors combined with, and developed in conjunction with, the physical skills of the sport allow the athlete to achieve his or her full potential (Chambers, 1997). To meet the broad physical demands of their sport, alpine skiers train strength and core stability, power, aerobic and anaerobic endurance, coordination/motor skills, balance, and mobility, together with supplementary training, often involving cross-training in other sports (Reid 2000; Hydren et al., 2013).

The research Of Dzimbova and Kirkova shows that training and competitions in alpine skiing disciplines enable the development of anaerobic capacity of athletes. From the analyzed results, it is clear the great importance of the anaerobic abilities of the athletes for better performance during the competition. (Dzimbova, T., Kirkova, M., 2020)

Another study says the type of motion pattern and musculature involved considerably differ between cross-country skiing and running. Roller skiing was originally created as a training method for cross-country skiing during the off-season, and the movement patterns and endurance required in roller and cross-country skiing are now considered quite similar. (Nakai A., 2020)

Gleadhill, S., Tomohiro K., Nagahara R., (2020) demonstrated possibly detrimental changes to RS, SL and SFsurrounding the manual release instant, however, demonstrated possibly beneficial anteroposterior net impulse changes. This sprint training modality may be incorporated into a well thought out periodised training

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program, however, results suggested that manually releasing resistance may have been the primary cause of performance and kinematic changes.

Strength training often targets the entire body, with special emphasis on the legs, core, and hip/gluteal region. Depending on the athlete's individual needs, strength training can focus on strength endurance, hypertrophy, maximal strength and/or power. Compared to other sports, there is special focus on stabilization of the core and hip/pelvis region (Hydren et al., 2013), as well as eccentric training to sustain the high loads and shocks encountered when turning (Ferguson, 2010; Hydren et al., 2013; Patterson and Raschner, 2015). Training of coordination/motor control, balance and quickness involves off-snow imitation of skiing and is often combined with strength, power, or endurance training (Rascher et al., 2004; Hydren et al., 2013).

Material & methods

The study includes a number of 10 athletes, aged 16, boys, who represent the members of the alpine skiing section, within a sports club, under private law. The athletes, the parents and the coach of the ski department, gave their consent for the present study, being informed about the content of the trainings, the training days, the venue, the time intervals and the necessary equipment.

Procedure: **Testing (1). Flexibility. "Sit & Reach"**

Procedure: Athlete sits with their feet up against the sit and reach box (any box will do). Reach forward with both hands while keeping their knees completely locked. Athlete then holds this position for the two (2) seconds. Measure to the nearest decimal and record the best of two (2) results.

Testing (2). "Maximum Push Up in 60 sec"

Procedure: The athlete lies on prone on the ground with their hands off the ground, ready to complete a pushup. On the signal to start, the athlete puts their hands on the ground and presses to lift their chest, hips, thighs off the ground simultaneously to a full extension of the arms position. The body must maintain this "rigidity" throughout the test The athlete then lowers their body down until the whole body is again in contact with the ground and the hands are off the ground (back to the start position). The athlete continues the method for 60seconds.Only correctly completed full pushups are counted in the total.

Testing (3). "Penta Jump"(5 Consecutive Jumps)

Procedure: Two legged jumps. Athletes start with both toes behind the line (against a box or wall). The athlete performs five (5) consecutive jumps in a continuous motion (rhythm). The athlete must land solidly with good stability. Final measurement is taken to the toe of the hindmost foot (ideally the feet should be at the same length). If the athlete loses balance forward or backwards, the test result will not count and should be repeated. The better of two (2) attempts will be scored.

Testing (4). "Single Leg Squat"

Procedure: Supporting knee should point same direction as foot throughout movement. Hip knee and big toe in alignment. Speed of movement is controlled speed, - 1 minute rest between legs - Failure is considered if speed of movement can't be controlled, if full range is not achieved, if balance can't be maintained, if knee buckles inward, if ankle stability can't be maintained.

Table 1. Test Protocol "Fitness Testing Protocol Ski End Snowboard Australia 2005"

No. crt.	Fitness TEST	Main Fitness Component/s Measured	Detailed Items Measured
1	Sit & Reach	Flexibility for hamstrings, gluteus and lower back.	Centimeters to the nearest decimal (toes =35cm).
2	Maximum Push Up in 60 sec all	Upper - Body Strength & muscular endurance Relative strength & endurance of the upper body (chest, posterior shoulder, triceps, core stabilizers.	Seconds (s)
3	Penta Jump (5 Consecutive Jumps)	Lover Body Strength – Explosive Power - Stability Lower body power and stability.	Meters (m)
4	Single Leg Squat	Lower Body Strength. Entire leg strength including gluteus, ankle and knee stability.	Reps (r)

Table 2. The values of the scores recorded in each test, for U16 -"Fitness Testing Protocol Ski, Australia", 2005

AGE U16	T_1 "Sit & Reach"	T_2 "Maximum Push Up in 60 sec"	T_3 "Penta Jump"	T_4 "Single Leg Squat"
Excellent	43+	50+	12.7+	17+
Very Good	37-42	40-49	11.4-12.69	13-16
Average	27-36	30-39	10.2-11.39	9-12
Below Average	16-25	20-29	8.7-10.19	5-8
Poor	< 16	< 20	<8.7	< 5

Data collection and analysis

During the experiment itself, in both pre-test and post-test evaluation, the results obtained at the four tests were recorded in the observation sheets of each athlete ("Sit & reach"; Maximum "Push Up in 60 sec ";" Penta Jump ";" Single Leg Squat "). All athletes benefited from the same conditions, both in the pre-test and in the post-test.

Statistical analysis

In the present study, a descriptive statistical analysis was performed on independent samples. The results obtained by the athletes, between the two moments: pre-test and post-test, were analyzed through the Program - SPSS, variant 10.1. Thus, for the comparative analysis of the results obtained by the 10 athletes, between the two moments of the test (October-November), "One Way Anova Test" was applied.

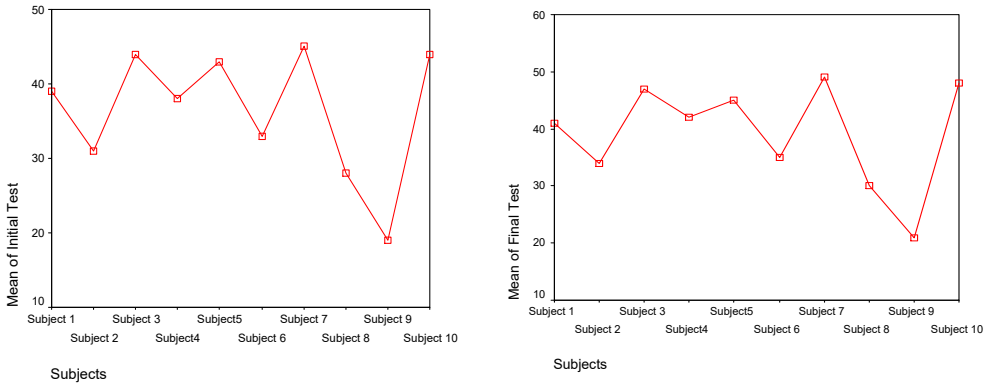
Table 3 shows the results of the basic parameters of descriptive statistics (arithmetic mean (mean), standard deviation (Std.Dev), standard Error, Confidence Interval (lower / upper bound), minimum and maximum.

Thus, based on the values obtained, after the application of the training program, a significant increase of the group average can be observed, between the final test (39,200), compared to 36,400, at the initial test. The standard deviation was at the final test of (9,065), compared to the initial test (8,5401).

Table 3. Results in the Pre – and Post intervention program – for "Sit & Reach"

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Initial Test	Subject 1	1	39.0000	.	.	.	.	39.00	39.00
	Subject 2	1	31.0000	.	.	.	.	31.00	31.00
	Subject 3	1	44.0000	.	.	.	.	44.00	44.00
	Subject4	1	38.0000	.	.	.	.	38.00	38.00
	Subject5	1	43.0000	.	.	.	.	43.00	43.00
	Subject 6	1	33.0000	.	.	.	.	33.00	33.00
	Subject 7	1	45.0000	.	.	.	.	45.00	45.00
	Subject 8	1	28.0000	.	.	.	.	28.00	28.00
	Subject 9	1	19.0000	.	.	.	.	19.00	19.00
	Subject 10	1	44.0000	.	.	.	.	44.00	44.00
	Total	10	36.4000	8.5401	2.7006	30.2908	42.5092	19.00	45.00
Final Test	Subject 1	1	41.0000	.	.	.	.	41.00	41.00
	Subject 2	1	34.0000	.	.	.	.	34.00	34.00
	Subject 3	1	47.0000	.	.	.	.	47.00	47.00
	Subject4	1	42.0000	.	.	.	.	42.00	42.00
	Subject5	1	45.0000	.	.	.	.	45.00	45.00
	Subject 6	1	35.0000	.	.	.	.	35.00	35.00
	Subject 7	1	49.0000	.	.	.	.	49.00	49.00
	Subject 8	1	30.0000	.	.	.	.	30.00	30.00
	Subject 9	1	21.0000	.	.	.	.	21.00	21.00
	Subject 10	1	48.0000	.	.	.	.	48.00	48.00
	Total	10	39.2000	9.0652	2.8667	32.7151	45.6849	21.00	49.00



Graphics 1. The averages obtained by the athletes between the initial and final testing Sit & Reach

From the graphs above, a significant increase in the results obtained can be observed, between the two moments of the Pre-and Post-test intervention program, for each subject, in the "Sit & Reach" test, to assess the flexibility of the lower train. Thus, in terms of the score obtained by athletes from the application of physical

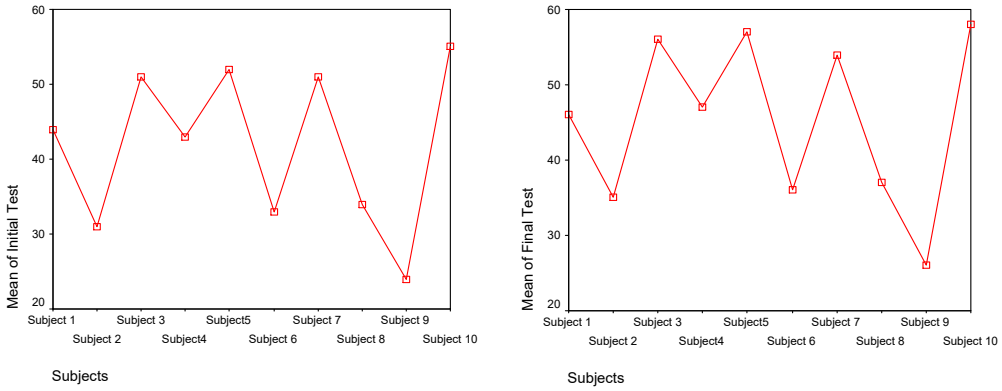
training program, there is an improvement in flexibility of the hamstrings, glutes, the buttock and back muscles and hip. Athletes with numbers 3, 5, 7 and 10, obtained an excellent score, followed by 1 and 4, with a very good score, and 2, 6 and 8, with an average score. The differences between athletes are obvious, given the level of physical condition, up to the time of testing, previous and personal motor experience.

Table 4 shows the results of the "Maximum Push up in 60 seconds" Testing. Based on the values obtained, after the application of the training program, a significant increase of the group average can be observed, at the final test of 45,200, compared to the initial test 41,800. The standard deviation was at the final test of (11,183), compared to the initial test (10,675).

Table 4. Results in the Pre - and Post intervention program – for "Maximum Push up in 60 seconds"

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Initial Test	Subject 1	1	44.0000	.	.	.	.	44.00	44.00
	Subject 2	1	31.0000	.	.	.	.	31.00	31.00
	Subject 3	1	51.0000	.	.	.	.	51.00	51.00
	Subject4	1	43.0000	.	.	.	.	43.00	43.00
	Subject5	1	52.0000	.	.	.	.	52.00	52.00
	Subject 6	1	33.0000	.	.	.	.	33.00	33.00
	Subject 7	1	51.0000	.	.	.	.	51.00	51.00
	Subject 8	1	34.0000	.	.	.	.	34.00	34.00
	Subject 9	1	24.0000	.	.	.	.	24.00	24.00
	Subject 10	1	55.0000	.	.	.	.	55.00	55.00
	Total	10	41.8000	10.6750	3.3757	34.1636	49.4364	24.00	55.00
Final Test	Subject 1	1	46.0000	.	.	.	.	46.00	46.00
	Subject 2	1	35.0000	.	.	.	.	35.00	35.00
	Subject 3	1	56.0000	.	.	.	.	56.00	56.00
	Subject4	1	47.0000	.	.	.	.	47.00	47.00
	Subject5	1	57.0000	.	.	.	.	57.00	57.00
	Subject 6	1	36.0000	.	.	.	.	36.00	36.00
	Subject 7	1	54.0000	.	.	.	.	54.00	54.00
	Subject 8	1	37.0000	.	.	.	.	37.00	37.00
	Subject 9	1	26.0000	.	.	.	.	26.00	26.00
	Subject 10	1	58.0000	.	.	.	.	58.00	58.00
	Total	10	45.2000	11.1833	3.5365	37.1999	53.2001	26.00	58.00



Graphics 2. The averages obtained by the athletes between the initial and final testing "Maximum Push up in 60 seconds"

From the graphs above, a significant increase of the results obtained can be observed, between the two moments of the Pre-and Post test intervention program, for each subject, in the "Maximum Push up in 60 seconds" test. Thus, from the point of view of the qualifications obtained by the athletes, following the application of the physical training program, there is an improvement of the resistance of the upper train, more precisely of the chest muscles, biceps, triceps and stabilizing muscles. The athletes with numbers 3, 5, 7 and 10, obtained the excellent score, being followed by 1 and 4, with a very good score, and 2, 6 and 8, with an average score. The differences between athletes are obvious, given the previous motor register, experience, adaptability to the body, as well as the native component.

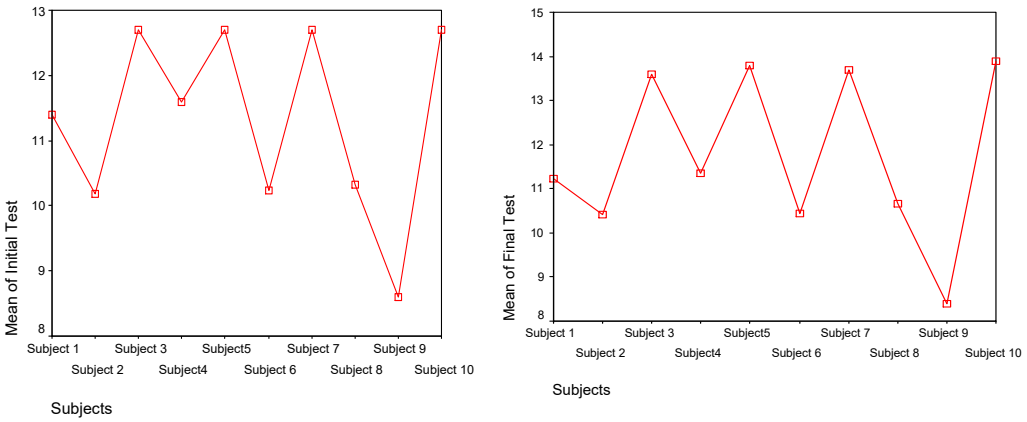
Table 5 shows the results of the "Testing Penta Jumps". Based on the values obtained, after the application of the training program, a significant increase of the group average can be observed, at the final test

of 11,749, compared to 11,313, at the initial test. The standard deviation was at the final test of (1,896), compared to the initial test (1,437).

Table 5 Results in the Pre – and Post intervention program – for "Penta jumps" (5 Consecutive Jumps)

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Initial Test	Subject 1	1	11.4000	.	.	.	.	11.40	11.40
	Subject 2	1	10.1800	.	.	.	.	10.18	10.18
	Subject 3	1	12.7000	.	.	.	.	12.70	12.70
	Subject4	1	11.6000	.	.	.	.	11.60	11.60
	Subject5	1	12.7000	.	.	.	.	12.70	12.70
	Subject 6	1	10.2300	.	.	.	.	10.23	10.23
	Subject 7	1	12.7000	.	.	.	.	12.70	12.70
	Subject 8	1	10.3200	.	.	.	.	10.32	10.32
	Subject 9	1	8.6000	.	.	.	.	8.60	8.60
	Subject 10	1	12.7000	.	.	.	.	12.70	12.70
	Total	10	11.3130	1.4371	.4545	10.2849	12.3411	8.60	12.70
Final Test	Subject 1	1	11.2300	.	.	.	.	11.23	11.23
	Subject 2	1	10.4200	.	.	.	.	10.42	10.42
	Subject 3	1	13.6000	.	.	.	.	13.60	13.60
	Subject4	1	11.3400	.	.	.	.	11.34	11.34
	Subject5	1	13.8000	.	.	.	.	13.80	13.80
	Subject 6	1	10.4500	.	.	.	.	10.45	10.45
	Subject 7	1	13.7000	.	.	.	.	13.70	13.70
	Subject 8	1	10.6500	.	.	.	.	10.65	10.65
	Subject 9	1	8.4000	.	.	.	.	8.40	8.40
	Subject 10	1	13.9000	.	.	.	.	13.90	13.90
	Total	10	11.7490	1.8968	.5998	10.3921	13.1059	8.40	13.90



Graphics 3. The averages obtained by the athletes between the initial and final testing "Penta jumps"

From the graphs above, a significant increase of the results obtained can be observed, between the two moments of the Pre - and Post test intervention program, for each subject, in the "Penta Jumps" test.

Thus, from the point of view of the score obtained by the athletes, following the application of the physical training program, an improvement of the explosive power at the level of the lower limbs is observed.

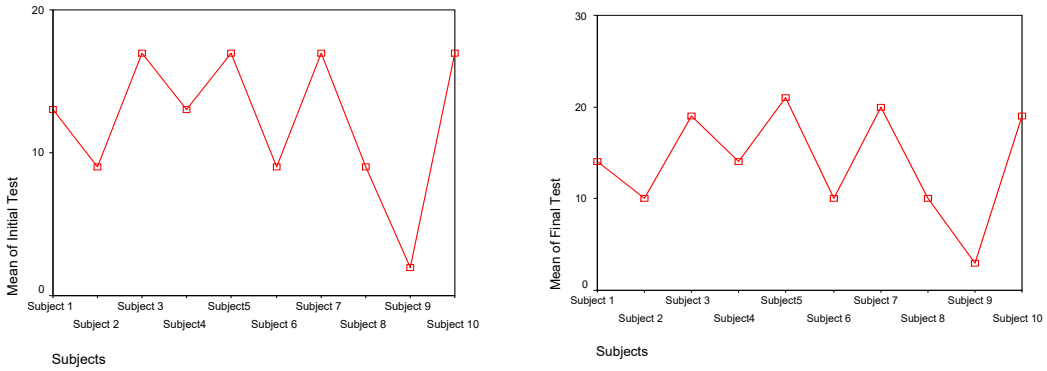
Athletes with numbers 3, 5, 7 and 10, obtained an excellent score, followed by 1 and 4, with a very good score, and 2, 6 and 8, with an average score. The differences between athletes are obvious, given the previous motor register, experience, adaptability to the body, as well as the native component.

Table 6 shows the results of the "Testing Single leg squad". Based on the values obtained, after the application of the training program, a significant increase of the group average can be observed, at the final testing of 14,000, compared to 12,300, at the initial testing. The standard deviation at the final test is (5,811) compared to the initial test (5,034).

Table 6. Results in the Pre - and Post intervention program for Single leg Squad

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Final Test	Subject 1	1	14.0000	.	.	.	.	14.00	14.00
	Subject 2	1	10.0000	.	.	.	.	10.00	10.00
	Subject 3	1	19.0000	.	.	.	.	19.00	19.00
	Subject4	1	14.0000	.	.	.	.	14.00	14.00
	Subject5	1	21.0000	.	.	.	.	21.00	21.00
	Subject 6	1	10.0000	.	.	.	.	10.00	10.00
	Subject 7	1	20.0000	.	.	.	.	20.00	20.00
	Subject 8	1	10.0000	.	.	.	.	10.00	10.00
	Subject 9	1	3.0000	.	.	.	.	3.00	3.00
	Subject 10	1	19.0000	.	.	.	.	19.00	19.00
	Total	10	14.0000	5.8119	1.8379	9.8424	18.1576	3.00	21.00
Initial Test	Subject 1	1	13.0000	.	.	.	.	13.00	13.00
	Subject 2	1	9.0000	.	.	.	.	9.00	9.00
	Subject 3	1	17.0000	.	.	.	.	17.00	17.00
	Subject4	1	13.0000	.	.	.	.	13.00	13.00
	Subject5	1	17.0000	.	.	.	.	17.00	17.00
	Subject 6	1	9.0000	.	.	.	.	9.00	9.00
	Subject 7	1	17.0000	.	.	.	.	17.00	17.00
	Subject 8	1	9.0000	.	.	.	.	9.00	9.00
	Subject 9	1	2.0000	.	.	.	.	2.00	2.00
	Subject 10	1	17.0000	.	.	.	.	17.00	17.00
	Total	10	12.3000	5.0343	1.5920	8.6987	15.9013	2.00	17.00



Graphics 4. The averages obtained by the athletes between the initial and final testing Single leg Squad

From the graphs above, a significant increase of the results obtained can be observed, between the two moments of the Pre-and Post test intervention program, for each subject, in the "Single leg Squad" test. Thus, from the point of view of the score obtained by the athletes, following the application of the physical training program, an improvement of the explosive power at the level of the lower limbs is observed. Athletes with numbers 3, 5, 7 and 10, obtaining the excellent score, being followed by 1 and 4, with a very good score, and 2, 6 and 8, with an average score. The differences between athletes are obvious, given the previous motor register and the differences due to the maturation effect.

Results

Table 7. Differences recorded between the two moments of the test Pre-Posttest, Descriptive statistics T-test

Testing	**Measure**	**Sportivi (n =10) Pre-test**	**Sportivi (n=10) Post-test**	**t-test**	**P- value**
Sit & Reach	(cm)	36.9	37.8	3.551	P<0.982
Maximum Push up in	(s)	41.8	45.2	2.80	P <0.945
Penta jumps	(cm)	11.313	11.749	3.39	P <0.979
Single leg Squad	(r)	25.34	33.78	3.78	P <0.963

The analysis of the average values suggests that between the two moments of the test, the values recorded at the group level, in the "Sit & Reach" test, for measuring flexibility, there is a statistically significant difference at ($p < 0.982$ and $t = 3.551$). And we can say that was a very strong positive correlation $p<0.982$ from Pearson correlation which means the more we apply the program the more flexibility will have which makes the results from final test better than before the program was applied which confirms our first assumption.

The analysis of the average values suggests that between the two moments of the test, the values recorded at the group level, at the "Maximum Push up in 60 seconds" test for measurement, strength and endurance, at the level of the upper train and abdomen, there is a statistically significant difference at ($p < 0.945$ and $t = 2.80$). And we can say that was a very strong positive correlation $p<0.945$ from Pearson correlation which means the more we apply the program the better upper body results will be which confirms our second assumption.

The analysis of the average values suggests that between the two moments of the test, the values recorded at the group level, in the "Penta jumps" test for measuring explosive force and power, there is a statistically significant difference at ($p < 0.979$ and $t = 3.39$). And we can say that was a very strong positive correlation $p<0.979$ from Pearson correlation which means the more we apply the program the stronger Penta jumps the better results will be which confirms our third assumption.

The analysis of the average values suggests that between the two moments of the test, the values recorded at the group level, at the "Single leg Squad" test for measurement, hamstrings muscle strength, glute there is a statistically significant difference at ($p < 0.963$ and $t = 3.78$). And we can say that was a very strong positive correlation $p<0.963$ from Pearson correlation which means the more we apply the program the better results will be at hamstrings muscle strength and stability which confirms our last assumption.

Discussion

Young children tend to be flexible, but flexibility performance tends to decrease with age after puberty, especially in males. This is presumably due to gains in muscle size, stature, and muscle strength, whereas females tend to remain flexible with maturation (Bompa, 2000). In the current study, flexibility increased in both significantly in the athlete with the number: 3, 5, 7 and 10.

In 1982, Song discovered that skiers have better flexibility than non-athletes, this may be due to the hip flexibility required for skiing performance (Song, 1982). Previous research has determined that flexibility is not associated with ski performance (Song, 1982). Poor agility can often berelated to a lack of neuromuscular function, flexibility and strength. SL performance demands a large contribution from agility (Song, 1982).

The increase in vertical jump heights and power output performances within creasing age found in the recent study can be related to maturation factors includingin creased jump coordination due to motor skill development, muscle mass, and stature (Johnson et.al., 1996; Matos et.al., 2007).

Jones et al. 2000, suggests the effects of increasing stature and mass during puberty may have more influence on physical fitness performance in males and not females.

As athletes mature their ability to coordinate these movement patterns improves. The extent of muscle development and performance depends on relative maturation of the nervous system and high levels of strength, power, and skill are impossible if the junior athlete has not reached neural maturity. In general, myelination of nerve fibers does not occur until sexual maturation is achieved (Brooks, et.al., 2005).

Conclusions

The primary purpose of this paper was to find the fitness level, in a group of U16 years old, boys, following the implementation of an 8-week physical training program, which targets the following components: (flexibility, strength and muscular endurance, in the upper limbs, explosive force / power in the lower limbs), which can provide a solid basis for preparation for performance.

Considering a practical context, after the application of an 8-week physical training program to improve physical condition, can be observed significant differences between the two moments of testing, both in the group and in the individual progress of the athletes, on the component of flexibility at the level of the hip, strength and endurance of the muscles at the level of the upper train, as well as of the explosive force and power, at the level of the lower limbs.

All young athletes should have a solid foundation of fitness level to withstand the demands of an entire alpine skiing competitive season. Most fitness programs are general, with similarities at the group level, with which you work, and thus, this aspect can reduce the possibility of progress, in terms of increasing fitness, on the specific components of alpine skiing. They do not yet specialize in racing disciplines, so it is important that the athletes develop an excellent general fitness base.

Thus, flexibility, upper and lower limb strength, endurance, explosive power, coordination, balance, along with aerobic / anaerobic capacity, should be integrated and implemented through means (games, application paths, circuits, approach to different sports, etc.). They can ensure the basis of the fitness level, as well as the progress towards performance, in the alpine skiing discipline.

This study clarified the application of an 8-week physical training for determinate the fitness level of the athletes and a new series of research must include flexibility, strength and muscular and explosive force also. The practical recommendations made may change in the future, after further research to established the

importance of using components: (flexibility, strength and muscular endurance, in the upper limbs, explosive force / power in the lower limbs components: (flexibility, strength and muscular endurance, in the upper limbs, explosive force / power in the lower limbs (if any) in a physical training program.

Conflicts of interest - If the authors have any conflicts of interest to declare.

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