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Agility performance of adolescent Polish recreational skiers

Małgorzata Pasławska[1], Beata Wojtyczek[2], Christian Raschner[3]

[1] Tertiary School of Tourism and Foreign Languages, Warsaw, Poland
[2] Józef Piłsudski University of Physical Education in Warsaw, Poland
[3] Department of Sport Science, University of Innsbruck, Innsbruck, Austria

ABSTRACT

Introduction. Downhill skiing is one of the most popular winter sports. It imposes very high requirements concerning technique and physical fitness, especially in terms of movement coordination. This is crucially significant for young people practicing recreational skiing because of the alarming shortage of physical activity in that age group. In Poland there are no up-to-date and consistent testing methods for evaluation of pre-season skiing fitness preparation and training of specific skiing abilities. In this regard, the experience of Austrians, who have been applying efficient training and testing methods for years and achieved numerous sporting successes, can be effectively used in Poland.
Aim of Study. The study aimed to evaluate the agility performance of Polish adolescent recreational skiers on the basis of the Speedy jump test and to develop Polish norms for this test.
Material and Methods. 282 boys (n = 154) and girls (n = 128) aged 13-16 years from two Warsaw junior high schools took part in the study. The subjects were divided into two groups: the control group consisting of non-skiing students (CN – attending the basic curriculum program and; CS – attending the sport-profiled curriculum program), and the experimental group consisting of recreational skiers. The tests were carried out in a gym hall, from October 2007 to February 2008. Jumping agility was tested with the Speedy jump test. Significant differences between mean values in the groups were determined with a variance analysis.
Results. Statistical analysis showed that mean values in the CS group were significantly different ($p < 0.001$) from the results in the E and CN groups. In each case the CS group achieved considerably better results in the Speedy jump test. Further analysis showed that 32% of girls and 31% of boys from group E achieved lower than average results in the Speedy jump test.
Conclusions. The study showed that the level of required jumping agility for skiers was unsatisfactory. The Speedy jump test results revealed that as many as one-third of researched skiers scored lower than average and because of that they might be more exposed to skiing injuries. There is an urgent need to introduce skiing preparation for young people based on reliable fitness training.

KEY WORDS

recreational alpine skiing, adolescents, skiing injuries, agility performance, specific fitness tests for skiers, Speedy jump test.

Introduction

Alpine skiing is one of the most popular winter sports in Europe. Each year millions of recreational skiers of different performance levels, age and gender spend their leisure time on the ski slopes. The diversity of skiers combined with faster equipment and increasing congestion on the ski slopes raises safety concerns [1]. The physical demands placed on the skiers have changed in the last decade due to such recent developments as the introduction of shorter skis with extreme side cuts and higher binding plates as well as changing environmental factors like aggressive artificial snow [2]. Epidemiological studies have shown a high incidence of serious injuries among adolescent alpine skiers [3]. The consequences of these injuries can be wide-ranging and have a substantial impact on the daily life of recreational skiers.

To reduce the number of skiing injuries and improve individual skiing performance in adolescent skiers more attention should be paid to the fitness levels in this age group. Even adolescent skiers should develop appropriate physical

fitness and skills in order to cope with the demands of skiing placed upon the musculoskeletal system. It is generally accepted that good physical requirements are responsible for sportive and safe skiing [4]. Studies also indicate that beside endurance and strength components, coordination and sensorimotor performance are of utmost importance in alpine skiing [5, 6, 7].

It is known from literature that the level of physical fitness in adolescents has declined dramatically over the last decades, and recommendations are given regarding appropriate physical activities with both short- and long-term health benefits in adults [8, 9]. The introduction of appropriately supervised programs could make all school age students increase their fitness level. Physical fitness tests can serve to identify those at an increased risk of becoming physically inactive young adults. They can be also used as entrance examination tools in sport-oriented schools.

In present-day Poland there are no uniform criteria of selection of prospective skiers, and recruitment to Sports Schools is often made in an intuitive way, with a general lack of coherency in the process of selection in winter sports [10, 11]. The only test battery designed for alpine skiers, i.e. Haczkiewicz's Special Fitness Test for Skiers [12], has been recognized as outdated and, to a considerable degree, inaccurate [13]. There is a need for the introduction of new testing and training methods, which can be easily arranged and administered in schools. Hence it is necessary to use test instruments which are more relevant to the conditions of contemporary skiing.

Such instruments have been commonly used in Austria, where numerous successes of alpine ski racers and ski academies (e.g. Skigymnasium Stams) are evidence of the existence of optimised environment that also includes fitness testing batteries. Fitness training quality can only reach a high level when the kinematic, dynamic and electromyographic characteristics of modern skiing techniques are known from biomechanical field research [2, 14, 15]. Fitness tests should cover ski specific parameters so that test results can be classified to determine current individual performance and evaluate individual performance progress. It is essential that ski racers in particular are exposed to physical testing at an early age and at regular intervals. This has been the case of Austrian adolescent racers from the Skigymnasium Stams (14-19 year olds) and provincial state ski teams (10-14 year olds) since 1996 [16]. The test battery used by these skiers includes specially designed test devices and computer programs (Table I).

Additionally, a special test battery (Table II) was developed for ski clubs with simple self-accomplishable tests [17, 18]. Some of these tests are general physical fitness tests such as the hurdle boomerang run [19], vertical/horizontal jump [20, 21] or the Cooper test [22], well-known in literature, but others have been designed by individual schools for their own purposes.

Table I. Skigymnasium Stams and provincial ski teams test battery

	Test	Purpose
1	Speedy jump (Stams version)	Coordination & agility
2	Isometric leg extension strength test	Maximal unilateral leg extension strength
3	Isometric flexion and extension strength test	Maximal strength of core muscles
4	Counter movement jump (CMJ) test on a force plate	Strength and power of lower limbs
5	Ski specific CMJ test	Ski specific strength and power of lower limbs
6	Drop jump test (40 cm)	Reactive strength
7	Box jump test	Strength endurance of lower limbs
8	S3 test	Balance right/left & forward/backward
9	Line run test	Anaerobic endurance
10	Cooper test	Aerobic endurance

Table II. Test battery for ski clubs

	Test	Purpose
1	Speedy jump (ski clubs version)	Agility & coordination
2	Hurdle boomerang run	Speed & orientation of upper and lower limbs
3	45 seconds jump	Strength and endurance of lower limbs
4	Stand and reach	Flexibility of lower limbs and spine
5	Vertical jump (jump and reach)	Strength and power of lower limbs
6	Standing long jump	Strength and power of lower limbs
7	Core strength – flexion	Strength endurance of core flexion muscles
8	Core strength – extension	Strength endurance of core extension muscles
9	Cooper test	Endurance

The Stams and Ski Clubs versions of the Speedy jump test are innovative tools of assessment of the level of agility qualities necessary for skiing. Draper and Lancaster noted already in 1985 that agility was the result of a combination of strength, speed, balance and coordination [23].

Aim of Study

The main aim of this study was to assess the agility performance of Polish adolescent recreational skiers on the basis of the Speedy jump test, and to develop Polish norms values for this test.

Material and Methods

Subjects and test procedure

282 healthy adolescents (154 boys and 128 girls) aged 13-16 years from two Warsaw junior high schools took part in this study. They were divided into two groups regarding their skiing experience. The control group (C) consisted of students who did not practice downhill skiing, whereas the experimental group (E) comprised students practicing recreational downhill skiing. Students from the control group were subdivided into those attending the basic curriculum program (CN) and those in a sport-profiled curriculum program (CS). The preferred sports in the CS group included taekwondo and the modern pentathlon. Students in the experimental group were selected only from those attending the sport-profiled program.

Students were tested in the gym halls of their junior high schools between October 2007 and February 2008. A general warm-up was carried out prior to the tests by teachers. Students' body height was measured to the nearest 0.5 cm. Body mass was measured to the nearest 0.5 kg. Body mass index (BMI) was calculated by dividing body mass by the square of body height. Students' age and anthropometric characteristics are presented in Table III (girls) and Table IV (boys).

The test protocol was given approval by the University of Physical Education in Warsaw and the measurements were performed according to the ethical standards of the Helsinki Declaration.

Table III. Age and anthropometric characteristics of girls from the CN, CS and E groups

Sex	Girls		
Group	E	CN	CS
Number of students	66	43	19
Age [years]	14.1 ± 0.9	14.3 ± 0.9	13.7 ± 0.8
Body mass [kg]	52.6 ± 7.7	53.6 ± 5.7	49.8 ± 6.5
Body height [cm]	165.8 ± 6.2	165.5 ± 4.7	162.2 ± 4.4
BMI [kg/cm^2]	19.1 ± 2.0	19.6 ± 1.7	18.9 ± 1.8

Mean values ± standard deviation
BMI – body mass index; E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

Table IV. Age and anthropometric characteristics of boys from the CN, CS and E groups

Sex	Boys		
Group	E	CN	CS
Number of students	72	57	25
Age [years]	14.3 ± 1.0	14.2 ± 1.0	14.3 ± 1.0
Body mass [kg]	62.2 ± 10.1	59.5 ± 10.6	56.3 ± 10.6
Body height [cm]	173.6 ± 9.5	172.2 ± 7.9	170.6 ± 9.8
BMI [kg/cm^2]	20.6 ± 2.1	20.0 ± 2.7	19.2 ± 2.2

Mean values ± standard deviation
BMI – body mass index; E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

Test device

Jumping agility was tested on a standardised hurdle obstacle course called the Stams version of Speedy jump test (Fig. 1). The Speedy jump test is a common instrument of assessment of agility skills required in skiing [5, 16, 18, 24].

The students were to complete 26 two-footed jumps along the obstacle course as quickly as possible. The course is designed in such a way to enable the performance of forward, backward and sideway jumps with hurdles of varied heights (from 15 cm to 36 cm). Each student was instructed to face the obstacle with the hips and shoulders perpendicular to the forward movement direction. The time was measured with a stopwatch to the nearest hundredth of a second. The warm up for this test consisted of two familiarisation trails of the course. Three test trials were performed and the best time was recorded. Studies of adolescent ski racers revealed an intraclass correlation (ICC) of 0.89 and 0.91 for female and male youth ski racers, respectively (Raschner et al.).

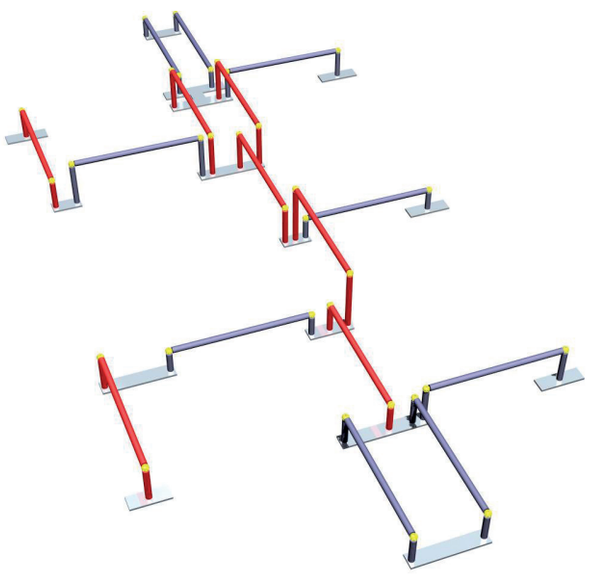

Figure 1. Speedy jump test (Stams version) (© C. Raschner, 2008, unpublished figure*)
*A detailed description of the course and particular tests in the battery can be obtained from the authors.

Statistical analysis

Jump time results are presented as mean values ± standard deviation (SD) as well as minimum and maximum values of all tested groups. Significant differences between mean values in the groups were determined with a variance analysis. For the purpose of post-hoc comparisons the Neuman-Keuls test (STATISTICA ver. 7.1, StatSoft, Inc. 2006, www.statsoft.com) was used. The level of statistical significance was set at $p \leq 0.05$. Figures 2 and 3, which include comparison data, show the results of the experimental group as the x-axis.

For the purpose of establishing norm values for adolescent Polish students the Speedy jump test results were normalized in relation to the mean values and SD of the E group. The norm value categories from extraordinarily poor to extraordinarily good were generated by designating the E group means plus/minus 0.5 SD as average. For calculating the range of the other categories a 0.5 SD was used.

Results

Table V shows the results of the Speedy jump test according to the student group, sex and age.

Statistical analysis showed no significant differences between the E and CN groups either among girls or boys. On the other hand, in the CS group the mean values were significantly different ($p < 0.001$) than in the E and CN groups. This was found both among the boys and girls (Fig. 2, 3). In each case the CS group achieved considerably better Speedy jump test results. Moreover, it should be emphasized that boys from the CN group scored higher than boys who were recreational skiers (group E).

In the further analysis of special motor skills the students were classified using the referential values as described in the method. In the groups of girls no significant correlations were found between age and Speedy jump test results. In the groups of boys there was such a correlation thus age

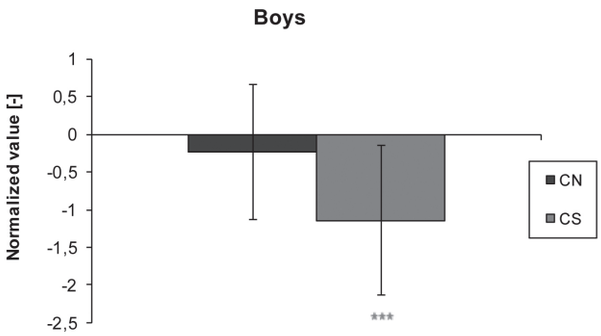

Figure 2. Normalized Speedy jump test results of boys from control groups (CN and CS) as compared with the experimental group (E). Significant differences are marked by asterisks: ***$p < 0.001$
E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

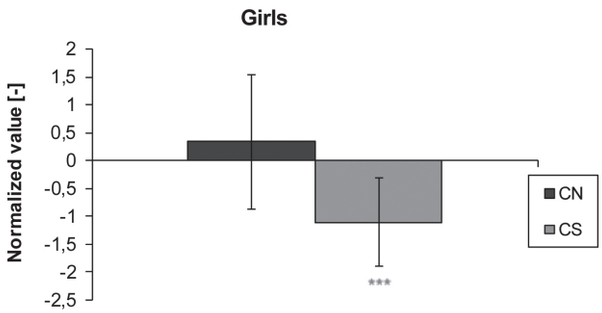

Figure 3. Normalized Speedy jump test results of girls from control groups (CN and CS) as compared with the experimental group (E). Significant differences are marked by asterisks: ***$p < 0.001$
E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

Table V. Speedy jump test results by group, sex and age

Group	Age	N	Mean values ± SD	Minimum	Maximum
Girls E	13	20	14.4 ± 1.7	11.5	17.0
	14	23	16.1 ± 1.4	13.7	18.9
	15/16	22	15.3 ± 2.0	12.0	20.7
Boys E	13	19	16.4 ± 1.9	12.8	19.7
	14	18	15.6 ± 2.2	12.9	20.3
	15/16	35	14.4 ± 1.9	11.4	19.7
Girls CN	13	10	17.2 ± 2.3	14.0	21.6
	14	13	15.2 ± 1.5	11.8	18.0
	15/16	20	15.9 ± 2.4	12.0	21.4
Boys CN	13	20	16.1 ± 1.9	12.5	20.0
	14	15	14.9 ± 1.9	12.1	17.6
	15/16	22	13.3 ± 1.3	11.3	16.3
Girls CS	13	9	13.2 ± 1.0	12.0	15.2
	14	6	13.8 ± 1.8	12.0	16.5
	15/16	4	13.5 ± 0.8	12.7	14.2
Boys CS	13	6	12.8 ± 0.9	11.7	14.2
	14	9	13.4 ± 1.6	11.0	15.2
	15/16	10	13.3 ± 1.4	11.9	16.3

E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

Table VI. Referential values of Speedy jump test (Stams version)

Referential values for the Speedy jump test (Stams version) [s]									
	Extraordinarily poor	Very poor	Poor	Below average	Average	Above average	Good	Very good	Extraordinarily good
Normalised values	(+∞; 2)	< 2; 1.5)	<1.5; 1)	<1; 0.5)	<0.5; –0.5>	(–0.5; –1>	(–1; –1.5>	(–1.5; –2>	(–2; –∞)
Girls aged 13-16 years	>19.22	19.22-18.14	18.14-17.10	17.10-16.13	16.13-14.35	14.35-13.53	13.53-12.76	12.76-12.04	12.04>
Boys aged 13 years	>20.65	20.65-19.46	19.46-18.33	18.33-17.27	17.27-15.34	15.34-14.45	14.45-13.62	13.62-12.83	12.83>
Boys aged 14 years	>20.12	20.12-18.84	18.84-17.63	17.63-16.51	16.51-14.47	14.47-13.55	13.55-12.68	12.68-11.87	11.87>
Boys aged 15-16 years	>18.46	18.46-17.31	17.31-16.23	16.23-15.22	15.22-13.38	13.38-12.54	12.54-11.76	11.76-11.03	11.03>

was taken into account while determining norm values (Table VI).

37% of girls from the E group attained average results, 31% higher than average and 32% lower than average. In the CN group 30% of girls achieved average results, 28% higher than average and 42% lower than average. Girls from the CS group had considerably different results than the rest of the students. Only 10% of them attained average results and the overwhelming majority (84%) higher than average results. Less than 5% of them scored lower than average (Fig. 4a).

The Speedy jump test results of the boys were similar to those achieved by the girls. In the experimental group (recreational skiers) students with average results constituted 36%. Results better that average were achieved by 33% of the boys and lower than average by 31%. In the CN group 39% of boys achieved average results and 40% higher than average. In comparison with girls from the same group, only 21% of the boys scored lower than average. In the CS groups 24% of boys attained average results, 62% higher than average, and only 4% lower than average (Fig. 4b).

Discussion

The study analyzed results of the Speedy jump test (Stams version), i.e. one of nine tests from an Austrian test battery developed for adolescent ski racers. This standardised hurdle obstacle course seems to be appropriate for assessment of agility – an important component of skiers' physical fitness [5, 16, 18, 24]. To avoid any risk of injury the course obstacles are made of flexible safety rubber elements. The correct performance of the test and achievement of good results require from adolescent students not only good coordination, but also an appropriate level of dynamic strength of the legs and good stabilization of torso muscles and motor speed. The whole motor system is involved in the performance of this test. The girls and boys must maintain their body balance in dynamic conditions, similar to real skiing. The achievement of a good jumping time in this test requires an extremely good sense of balance and an effective activation of the involved muscle groups, as well optimal coordination between them. It was observed that decreased core stability may predispose adolescent ski racers to knee injuries. Hildebrandt et al. noted that poor

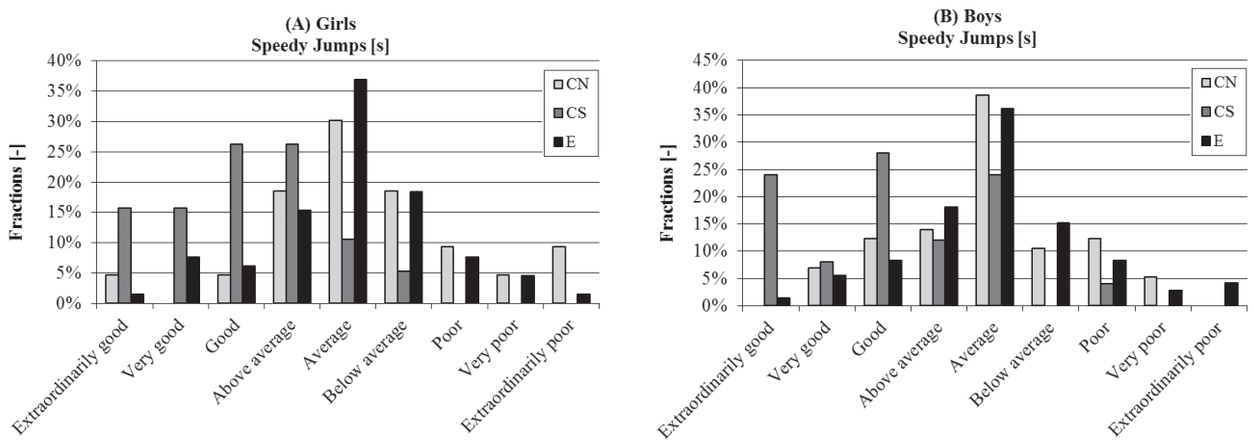

Figure 4. Classification of E, CN and CS group performances with regard to the established Speedy jump test reference ranges (Stams version)
E – experimental group; CN – control group – students attending a general curriculum program; CS – control group – students attending sport-profiled classes.

core strength and core flexion/extension strength imbalance contribute to lower extremity injuries in 14-19 year-old male and female ski racers [1]. This is in line with other studies showing that decreased core stability may predispose the body to knee injury [25, 26]. Next to core strength neuromuscular deficits were also documented as factors contributing to ACL injuries [27, 28]. The high ground reaction forces during skiing coupled with an increased variation in postural stability is associated with a higher risk of lower extremity injury. While carving, the skier should adapt his or her technique to changing conditions (e.g. flat or steep slopes, poor visibility) while gliding on heterogenic surfaces (e.g. moguls, ice sheets, deep snow).

The results of the Speedy jump test showed that the experimental group achieved considerably worse results than the CS group. Moreover, we found no significant differences between the E group (recreational skiers) and the CN group consisting of non-training general curriculum students.

In the majority of the analysed cases the level of assessed motor quality was average or higher than average. However, as many as 35% of amateur skiers and 32% of non-skiing students achieved results below or even far below average. On the other hand, none of the subjects from the CS group scored below average. Surprising is the fact that the E group had a high percentage of students with low levels of jumping coordination performance. One can speculate that except for the increased activity in the winter season the students from the experimental group had insufficient physical activity, which in turn had a profound effect on their general fitness. Moreover, skiing skills alone, which are not supported by earlier qualifying tests, and increased all-year-round physical activity are not enough to make a good and safe skier. An insufficient level of movement coordination could be dangerous in downhill skiing [24, 29], which is classified as an increased risk or even extreme sport [30]. It should be taken into account that the amateur student skiers were selected for the study from general curriculum classes and hence their physical fitness preparation level was rather poor. Therefore, students who are applicants for school ski camps should participate in pre-season conditioning programs. Beside endurance and strength exercises such programs must also include elements of coordination and agility training.

The calculation of our own reference values was necessitated by the lack of existing classification norms of adolescent Polish students practicing amateur downhill skiing, and the fact that the used Austrian norms referred to results of high level adolescent ski racers. The establishment of this specific agility performance references enabled a qualitative evaluation of the pre-season fitness preparation for recreational adolescent skiers in Poland as well as a comparison with control groups. Hergenroeder stressed the importance of a pre-season physical examination for detection of conditions that may pre-dispose athletes to injury [31]. One can speculate that this can be also true for adolescents practicing recreational skiing or general daily activities. To improve security on ski slopes children and adolescents should receive proper training by such institutions as schools. Only education from the earliest years in family and at school constitutes a foundation for good skiing practice [32]. All possible attempts should be made to enable young people's safe self-development – which should be realised in their free time as fully as possible during ski trips [33]. The conclusions of the study were made available to the school faculty and physical education teachers in the involved Warsaw junior high schools. Statistics of accidents among the youngest skiers point to the necessity to pay much more attention to pre-ski exercises before the season, both as part of physical education classes and as properly supervised individual preparation [34]. Another important action to reduce the risk of accidents on ski slopes is to ensure that recreational skiers are sufficiently familiar with the skiers' code published by the International Ski Federation (FIS) [1]. Studies show that especially beginners and young skiers display an insufficient knowledge of FIS rules and point to the need of development of appropriate educational campaigns at schools. Unfortunately, a limitation of the present study is that only one test from a battery of nine evaluating skiers' special fitness was analysed. The discussed issues still require further research.

Conclusions

1. Downhill skiing is an extremely popular form of physical activity, but at the same time it is also technically complicated and may cause a great number of injuries. Hence it requires properly channeled long-term fitness training.

2. Until now in Poland there has not been any consistent and specialist method for evaluation and training of special skiing skills required for safe participation in skiing.

3. The Austrian assessment methods and instruments, which are also used to improve special skiing abilities, can serve as helpful models. One of interesting tests is the Speedy jump test used for agility assessment and training, which is extremely important for safe and successful skiing.

4. The Speedy jump test results reveal that the level of pre-season fitness preparation of adolescent skiers in Poland is unsatisfactory. One-third of the tested skiers achieved results worse than average, displaying an insufficient level of agility.

5. Polish adolescents practicing amateur downhill skiing urgently need proper skiing education and updated training and testing methods, which should be used before each ski season.

6. One of the most significant factors that can diminish the risk of a skiing injury is a proper level of fitness preparation before each skiing season.

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Correspondence should be addressed to: Małgorzata Pasławska, Promyka 1 St./116, 01-604 Warsaw, e-mail: gosiapas@o2.pl

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