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**Original research article**

## **INFLUENCE OF MORPHOLOGICAL CHARACTERISTICS, PHYSICAL FITNESS AND SKI TECHNIQUE ON SKI RACING PERFORMANCE IN GIRLS AGED 12 TO 14**

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**Abstract.** *The purpose of this study was to use a multiple regression analysis to identify the independent impact of morphological dimensions, physical fitness and technique in free and competitive Alpine skiing on competition performance in twenty categorized racers from various Slovenian ski clubs, girls aged 12 to 14. We used the reduced model variables of morphological dimensions - MD (the volume of the left knee, body mass index (BMI), % body fat), physical fitness - PHF (ten jumps on both legs, running eights, stability test), technique in free skiing - TEFSK (balance, movement coordination and derivation of the curve) and the technique in competitive skiing - TECSK (balance, derivation of the curve and the line of skiing). For the criterion variable, we used the total sum of the points in the Slovenian Cup in the 2013/14 season. The results showed that all four areas of measurement explain 82.6% of the variance of the points won ( $R^2 = .826$ ), so the effect of these predictors on the competitive performance of the girls is very high (level set at  $p < 0.05$ ). This may show that the results of technique in competitive skiing ( $p < .000$ ) in girls significantly explains the share of points won. The regression coefficients show that girls with better morphological dimensions and better technique in free skiing achieved higher scores. The study raises key areas of research in the field of technique in free and competitive skiing as the two are fundamental for achieving top results in competitive Alpine skiing.*

**Key words:** *Alpine skiing, anthropometric measurements, motor abilities, technique.*

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## INTRODUCTION

Modern Alpine skiing is characterized by aggressive equipment and an adapted skiing technique with carving turns. The evolution of ski equipment, especially the development of the most extreme side cut of the ski and anti-vibration plates under the bindings, has made the sport of Alpine ski racing more dynamic and attractive. Carving turns are necessary (Müller & Schwameder, 2003), which consequently increase the centrifugal force on the skier as well as the angle of inclination of the ski (Raschner et al. 2001). In the case of a competitive giant slalom, skiing lines have become more direct, which means saving time driving on the edge, but also requires a good skating ability, quicker reactions and actions of competitors themselves by not turning and cornering. Through a systematic interpretation of Joubert's classic *Skiing - An art, a technique* (1978), or LeMaster's *The skier's edge* (1999) and introductory materials such as Loland and Haugen (2000), we came to the basic hypotheses, principles and terms of the technique of Alpine skiing. In Joubert's (1978) terminology, technical elements are builder element techniques. Thus, technical elements operate in a series of small, partial service, or motion patterns that may be connected to well-functioning, technical performance and represent good skiing. If we have a skier with good balance and the good ability to search for suitable snow support, we can say that our skier is technically well-prepared. Still, this does not mean that technically well-prepared skiers ski faster with gentle pressure on the snow or slower and rougher. If they create too rough ground pressure in bends, the edges recess deeper into the snow base, which means more friction and slow skiing (Loland & Haugen, 2000). Other skiers may be weaker, unstable in the balance of variations in their journeys between slips in turns and carving, which again means a loss of speed. Top skiers have the ability to maintain their cutting-edge techniques as well as adequate pressure on the snow base in order to regulate the minimum loss and maximum acquisition of speed at all sections of the track. In this respect, we are speaking of excellent skiers whose special quality of skiing represents the gliding skills during and even in curves. Alpine skiing is characterized as highly intensity sport that requires repetitive phases of high forces combined with isometric and eccentric - concentric contractions. Vogt & Hoppeler (2012) argue that modern competitive Alpine skiing involves high intensive tasks of durations spanning from 60 to 150 seconds with typical high values of strength and endurance (Andersen & Montgomery, 1988). During the preparation period in the younger categories, trainers should be particularly focused on learning multi-functionality, sport specific skills and complex motion sequences. These basic parameters should be taught and acquired between the ages of 10 to 14 (Malina, Bouchard, & Bar-Or, 2004).

**Research aims and objectives**

The main purpose of this study is to explain, with the multiple regression analysis, how important the impact of morphological dimensions, physical fitness and technique is in free and competitive skiing through the criterion variable – the total sum of points in the Slovenian Cup in the 2013/14 skiing season. Previous studies related to the identification of parameters for success in Alpine skiing are very complex and cover areas that cannot be serviced by the small number of included participants (N=20).

## METHODS

### **The sample of participants**

The study was carried out during the 2013/14 ski season was conducted on a sample of 20 categorized young female athletes in Alpine skiing. The children - girls  $M = 12.55$ ;  $SD = 0.510$  were healthy without standing out from their peers and they all had points in the Rauch Slovenian Cup for children.

### **Instruments and procedure**

#### *Measurements of morphological dimensions*

The measurements of morphological dimensions were held before the start of the 2013/14 ski season. All three variables of morphological dimensions: the circumference of the left knee (cm), body mass index ( $\text{kg}/\text{m}^2$ ) and the proportion of fat (%) were obtained using a device NX-16 (TC2) 3D Body Scan.

#### *Measurements of physical fitness*

Data measurements of physical fitness were obtained with established tests: ten jumps on both legs (m), running - eights (s) and a test of stability ((°)), which is measured by using the Biodex balance system.

The selection of three variables of morphological characteristics and physical preparation were based on previous research (Bandalo & Lešnik, 2011). In a longitudinal comparative study, they obtained different results in a similar battery of tests and participants of the same age. During our study, we were also interested in the connection between the skiing skills as techniques in free and competitive Alpine skiing.

#### *Measurements of technique in free and competitive Alpine skiing*

The Technical Field was rated in racing conditions to include the variables of balance, skiing lines and derivations in curves. In free skiing, we used the following variables: balance, derivation in curves and coordination of movements during changing curbs between turns. Under the term sports technique, we include the biomechanically correct, economical, smooth and effective implementation of motor functions in the movements (Weineck, 2007).

The evaluation techniques were conducted by three verified independent evaluators and state examiners at the Association of Teachers and Trainers of Slovenia (ZUTS). Elements of techniques were assessed by means of an evaluation (numerically-descriptive) scale from 1 to 3, with 1 as the lowest score and 3 as the highest.

### **Statistical analyses**

The data was analysed using the SPSS 21 for Windows. We used the multiple regression analysis to determine the statistical significance of the impact of physical fitness, morphological dimensions and technique in free and competitive Alpine skiing on the success of girls aged 12 to 14 in competitive Alpine skiing.

## RESULTS

The independent effect of the variables of the morphological dimensions, physical fitness, techniques in free skiing and techniques in competitive skiing on the points scored by the racing performance of girls in the Cup were determined using a multiple regression analysis. Table 1 shows the crude (b), standardized regression coefficients ( $\beta$ ), the coefficient of multiple correlation (R), and the total correlation coefficient (adj.R2) of the racing performance for girls.

**Table 1** Results of the multiple regression analysis of the impact of the four components (predictors): MD Component, Component PHF, Component TEFSK and Component TECSK on racing performance in Alpine skiing (criterion) in a group of girls in the U14 category

Predictors	B	SE	$\beta$	t	p	Collinearity tolerance	VIF	R	R <sup>2</sup>	p
Component MD	30.320	15.327	.219	1.978	.067	.946	1.057	.909	.826	.000
Component PHF	11.356	17.328	.082	.655	.522	.740	1.350			
Component TEFSK	30.647	16.307	.221	1.879	.080	.836	1.196			
Component TECSK	107.359	17.673	.776	6.075	.000	.712	1.405			

The results show that there is a statistically significant correlation between the predictors (morphological dimensions, physical fitness, technique in free skiing and technique in competitive skiing) and racing performance - or the sum of points in the Cup for girls in the category U14 ( $p=0.000$ ). All four categories explain 82.6% of the variance in points earned ( $R^2=.826$ ), so the effect of these predictors in the competitive performance of the girls is very high. From Table 1 it can be seen that results in terms of competitive skiing technique ( $p<.000$ ) in girls significantly display the share of the total sum of points won. The regression coefficient ( $\beta=0.776$ ) shows that girls with better grade techniques in competitive skiing are better than their peers in terms of the total sum of points in the Cup competition. A noteworthy tendency affects the MD Components ( $p=0.067$ ) and Components TEFSK ( $p=0.080$ ). The regression coefficients show that girls who achieve higher scores in the Cup are better in terms of morphological dimensions and in technique in free skiing.

## DISCUSSION

The combination of a well-developed capacity for anaerobic and aerobic potential, great muscle strength and several types of complex motor skills such as balance, agility or coordination were identified as predictors of performance in Alpine skiing (Berg & Eiken, 1999; Neumayr et al., 2003; Turnbull, Kilding, & Keogh, 2009). The Austrian Ski Federation attaches great importance to the various exercises in their programs in the fields of gymnastics, track-and-field sports, agility and coordination oriented to the field of strength training for the success of their athletes in competitions. The highlight of this thesis is that the Austrian Ski Federation prescribed evaluation techniques of Alpine skiing in free skiing - skiing outside formation, in their competition calendar for younger athletes in Alpine skiing at the beginning and end of each ski season. This encourages

coaches to a certain extent to focus attention on exercises specifically for free skiing, acquiring technical skills and the physical preparation of young athletes knowing that, over the years, it has become increasingly difficult to repair and replace imbalances in this type of preparation.

A lot of clarity is available for performance in Alpine skiing through research in the fields of anthropometry, motor abilities and physiology (the dimensions of the heart, aerobic and anaerobic power), the power of the lower extremities, body composition, biomechanical, electromyography, kinetic methods, computer simulations (Müller & Schwameder, 2003), analysed kinematic factors (speed, friction, acceleration, skiing lines) and physical environmental factors (equipment, lubricates, temperature, snow structures, Ferrario, Sforza Michielon, Dugnani, & Mauro, 1997).

Special emphasis should be placed on techniques in free skiing in the future because free skiing occupies a high percentage (about 70%) of all derivative turns in the career of every Alpine skier. Otherwise, it should include quality and interesting training techniques in free skiing before moving to training between poles, which would provide a smoother transition and development of situational racing techniques for various configurations, preparations and layouts. It is therefore an extremely important quality for the fundamental conquest techniques of Alpine skiing at all difficulty levels outside of the layouts as well as for the importance of obtaining special physical skiing abilities and feelings for items such as gliding, softness, different rhythms, timing, accuracy in the execution of the settings in technique, all along with the speed and quick reaction times for changing directions while skiing.

## CONCLUSION

The connection between the typical skiing actions and special skiing skills with physical preparation has been quite neglected in the past.

This study brings a thoroughly new dimension and a complex, multi-dimensional view to the evaluation of competitive performance in Alpine skiing for the period of late childhood and adolescence. Within the measurement system, we included, for the first time in Slovenia, a technical field in free and competitive skiing as a predictor, which is very highly correlated with the underlying physical ability – coordination, which has a high impact on competition success in Alpine skiing in children's categories.

## REFERENCES

- Andersen, R.E., & Montgomery, D. L. (1988). Physiology of Alpine skiing. *Sports Medicine*, 6(4), 210-21.
- Bandalo, M., & Lešnik, B. (2011). The relationship between selected anthropometric and motor variables with the competitive performance of young athletes in alpine skiing. *Kinesiologia Slovenica*, 17 (3), 16–31.
- Berg, H.E., & Eiken, O. (1999). Muscle control in elite alpine skiing. *Medicine and Science in Sport and Exercise*, 31(7), 1065-1067.
- Ferrario, V.F., Sforza, C., Michielon, G., Dugnani, S., & Mauro, F. (1997). A mathematical method for the analysis of trajectories in giant slalom. In E. Mueller, H. Schwameder, E. Kornexl, & C. Raschner, (Eds.), *Science and Skiing* (pp107-115). London: E & FN Spon.
- Joubert, G. (1978). *Skiing - An art, a technique*. Boulder, CO. Poudre Press.
- LeMaster, R. (1999). *The skier's edge*. Champaign, Ill.: Human Kinetics.
- Loland, S., & Haugen, P. (2000). *Alpin skiteknikk (Alpin skiteknikk)*. Norges Idrettshøgskole. In Norwegian

- Malina, R.M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation and physical activity*. Champaign: Human Kinetics.
- Müller, E., & Schwameder, H. (2003). Biomechanical aspects of new techniques in alpine skiing and ski-jumping. *Journal of Sports Sciences*, 21(5), 679-692.
- Neumayr, G., Hoertnagl, H., Pfister, R., Koller, A., Eibl, G., & Raas, E. (2003). Physical and physiological factors associated with success in professional alpine skiing. *International Journal of Sports Medicine*, 24(8), 571-575.
- Raschner, C., Schiefmüller, C., Zallinger, G., Hofer, E., Müller, E., & Brunner, E. (2001). Carving turns versus traditional parallel turns – a comparative biomechanical analysis. In: E. Müller, H., Schwameder, C., Raschner, S., Lindinger, & E. Kornel (Eds.), *Science and Skiing II* (pp. 203-217). Hamburg.
- Turnbull, J.R., Kilding A.E., & Keogh, J.W.L. (2009). Physiology of alpine skiing. *Scandinavian Journal of Medicine and Science in Sports*, 19(2), 146-155.
- Vogt, M., & Hoppeler, H. (2012). Competitive alpine skiing: Combining strength and endurance training: Molecular bases and applications. In E. Müller, S., Lindinger, & T. Stöggl, (Eds.). *Science and Skiing V* (pp. 38-47). UK: Meyer & Meyer Sport.
- Weineck, J. (2007). Optimales training. Leistungsphysiologische Trainingslehre unter besonderer Berücksichtigung des Kindes und Jugendtrainings (Optimal training. Performance physiology oriented exercise testing and prescription with particular consideration of training for children and adolescents). Spitta, Balingen. In German

## **UTICAJ MORFOLOŠKIH KARAKTERISTIKA, FIZIČKOG FITNESA I SKI TEHNIKE NA PERFORMANSE SKI TAKMIČARA DEVOJČICA UZRASTA OD 12 DO 14 GODINA**

*Cilj ove studije je bio da se višestrukom regresionom analizom identifikuju nezavisni uticaji morfoloških dimenzija, fizičkog fitnesa i tehnike u takmičarskom alpskom skijanju, na uzorku od dvadeset kategorizovanih devojčica skijaša, uzrasta od 12 do 14 godina, iz različitih slovenskih ski klubova. Koristili smo reducirane modele varijabli morfoloških dimenzija - MD (volumen levog kolena, indeks telesne mase (BMI), % telesnih masti), fizički fitness - PHF (deset skokova sunožnim odrazom, trčanje osmica, test stabilnosti), tehniku u slobodnom skijanju - TEFSK (ravnoteža, koordinacija pokreta i izvođenje zavoja) i tehniku u takmičarskom skijanju - TECSK (ravnoteža, izvođenje zavoja i linija skijanja). Kao kriterijumsku varijablu koristili smo ukupnu sumu bodova na Kupu Slovenije u sezoni 2013/14. Rezultati su pokazali da sva četiri izmerena prostora objašnjavaju 82.6% varijanse osvojenih bodova ( $R^2 = .826$ ), tako da je efekat ovih prediktora na takmičarske performanse devojčica veoma visok (nivo značajnosti  $p < 0.05$ ). Ovo može pokazati da rezultati tehnike u takmičarskom skijanju ( $p < .000$ ) kod devojčica značajno objašnjavaju udeo osvojenih bodova. Koeficijenti regresije pokazuju da su devojčice sa boljim morfološkim dimenzijama i boljom tehnikom u slobodnom skijanju ostvarile bolje rezultate. Ova studija pokreće ključne oblasti istraživanja u oblasti tehnike u slobodnom i takmičarskom skijanju, jer predstavljaju fundamentalne elemente za postizanje vrhunskih rezultata u takmičarskom alpskom skijanju.*

*Ključne reči: alpsko skijanje, antropometrijska merenja, motoričke sposobnosti, tehnika.*