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Original Article

Anthropometric profile of Greek alpine ski athletes

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Abstract:
The aim of this study was: 1) the recording and analysis of anthropometric characteristics of Alpine ski athletes divided into three different categories based on age, 2) determination of the anthropometric profile of the Greek skier in a pilot stage compared to other countries, 3) to check the impacts age and ski training experience might have on the extent of the body proportions or asymmetry. 21 athletes from Arachova ski club (Greece) participated in the research. Based on age the athletes were divided in three groups: Group A (12-13 years old 12.6, ± 0.55), Group B (14-15 years old 14.7 ± 0.49), Group C (over 16 years old 17.6 ± 1.88). The anthropometric parameters are recorded in a protocol included the following measurements: somatometric, skinfolds, body proportions or asymmetry, body composition, body type and body profile using the Heath & Carter method. A one way ANOVA (F-test) have used for all the three group categories. The three body types of the athletes (endomorph, ectomorph and mesomorph respectively) are defined by the following parameters: the body fat index (sum of 3 body fat measurements), the ponderal index and the 5 somatometric parameters (height, elbow width, knee width, arm perimeter, tibia perimeter). The asymmetries of the body in all three age groups showed large lower limbs and large width of the pelvis. Whereas the length of the body was normal, with respect to the age of the athletes.. The waist-hip ratio (WHR) in all three age groups showed a "perimetric type." Group C (over 16 years old) tended towards the mesomorph type, Group B (14-15 years old) towards the ectomorph type and Group A (12-13 years old) towards the endomorph type. Also, there was a significant correlation between age and the following body types: mesomorph and ectomorph type.
Key words: alpine ski, skier, anthropometry, body type.

Introduction

Anthropometry (biometrics sector) is one of the basic methods of research in the science of anthropology. Golab & Chrzanowska (1998, 2007) mention the following: in physical education, sport and motor rehabilitation emphasis is given to somatometrics, which is a sector of anthropometry and deals with the measurements of the whole body except the head (cefalometria). The somatometric characteristics of the skiers result from the techniques of body composition analysis and are subject to the science of anthropometry, which belongs to the group of direct methods. The most common methods are indirect analyses, which assess bone, fat and lean mass, and apply in laboratory, ergophysiology and ergometric studies, as well as in everyday clinical practice. Also, indirect human body analysis methods include the skinfold sum, the total body water (TBW), air-displacement plethysmography, radionuclide evaluation of the whole body water and potassium, bioelectrical impedance analysis (BIA), dual energy X-ray absorption (DEXA), as well as CT and MRI (Golab & Chrzanowska 1998, 2007, McArdle et al. 2001). Regarding the Alpine racing ski, except of the physical skills and technical training (skills), physical qualifications are also required. Based on the review of the anthropometric characteristics, body composition and body type of the winter sports athletes in development age the following authors have been occupied with: Golab W. & Golab S. (2005), Emeterio & González-Badillo (2010), Högström et al. (2012). Most researchers have studied adults and experienced athletes (Hymes et al., 1980; Sobiecki, 1994; Golab S. and Golab W., 1995; Sobiecki et al., 1996; Sobiecki and Szalkiewicz, 2005; Malousaris et al., 2008; Tsolakis et al., 2006; Tsolakis & Vagenas, 2010; Stöggl et al., 2010).

The aim of this study was: 1) the recording and analysis of anthropometric characteristics of Alpine ski athletes divided into three different categories based on age, 2) determination of the anthropometric profile of the Greek skier in a pilot stage compared to other countries, 3) to check the impacts age and ski training experience might have on the extent of the body proportions or asymmetry.

Material & methods

21 athletes from Arachova ski club (Greece) participated in the research. Based on age the athletes were divided in three groups: Croup A (12-13 years old 12.6□0.55), Group B (14-15 years old 14.7□0.49), Group C

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(over 16 years old 17.6□1.88). The above athletes had a training experience between 4.4 to 10.6 years in Alpine skiing, while some athletes were members of a national team.

Table 1. The individual characteristics of Alpine ski athletes: mean value standard deviation from age and training experience.

AGE CATEGORY	**12-13 years** (n = 5)	**14-15 years** (n = 7)	**Over 16 years old** (n = 9)	**Total** (n = 21)
Age (years)	12.6 ±0.55	14.7± 0.49	17.6± 1.88	15.4 ± 2.40
Training experience (years)	4.4 ± 1.34	7.9 ± 2.85	10.6 ± 3.78	8.2 ± 3.83

Data collection process

In the present study, to evaluate the anthropometry of the sample of the participating athletes, the following measurements took place: somatometric, skinfold measurements and use of the fat measurements sum method, body proportions or asymmetry measurements and body composition based on special indicators, body type and somatogram measurements with the Heath & Carter method (1967, 1990). All these measurements were conducted on the dominant side of each participant and are recorded in the protocol (Table 2 & 3). Also, measurements were made by the same meter indoors during the evening.

The size and mass of the tested body were measured approaching ± 0,1cm and ± 0.1kg respectively. For calculating the distance between the two points of the body and the perimeters, measuring tapes and fat measures were used respectively. Anthropometric characteristics, body composition and components of body type are calculated via descriptive statistics indexes (Chrzanowska 1997, 2004, Golab & Chrzanowska 1998, 2007).

The skinfolds were taken using a skinfold meter (Harpenden with ± 1mm approach), while the proportion or body asymmetry measurements were made based on specific indexes (Carter & Heath 1990, Golab & Chrzanowska 1998, 2007) as follows:

Lower Limbs Index = Lower limb length / Height * 100, Torso length index = Torso length/ Height * 100, Pelvis-shoulder Index = Hip width / Thorax width * 100, Body Mass Index (BMI) = Body mass / Height² (Kg/m²), Ponderal index = Height / $\sqrt[3]{}$ Body mass (cm/kg), Waist to hip ratio (WHR) = Zone perimeter/ Hip perimeter, Body Fat index (% BF) = [(4,950 / D) – 4.500] x 100 (equation of Siri, Durnin & Rahaman 1967, Golab & Chrzanowska 2007), D – Body density (g/cm³), D = 1,1034 - (0,002313* X1) (equation of Brozek & Keys, Golab & Chrzanowska 2007), X1 – Triceps fat measurement (mm), Fat mass (FM) = BM / % BF (kg), while BM – Body Mass, Lean Body Mass (LBM) = BM – FM (kg), Sum of 3 fat measurements = Triceps fat measurement (mm) + subscapularis fat measurement (shoulder - mm) + Abdomen fat measurement (abdomen - mm).

The three forms of the athletes body type (endomorph, ectomorph and mesomorph respectively) were determined according to the anthropometric protocol (Carter & Heath 1990, Golab & Chrzanowska 1998, 2007) based on the following parameters: the body fat index (sum of 3 fat measurements), the ponderal index and the 5 somatometric parameters (body height, elbow width, knee width, arm perimeter, tibia perimeter) where the body height was the benchmark, while the overall deviations of the other parameters (D) gave the final result via type II = 4 + (D / 8).

Based on these measurements, each body type has been determined based on three specific numbers (codes or points) accordingly placed on the somatogram. The somatogram contained two coordinates "X" and "Y" and three fields. The coordinate values are calculated as follows: X = ectomorph-endomorph, while Y = 2 (mesomorph) - (ectomorph + endomorph).

Statistical Analysis

The statistical data analysis was based on research - model for the above measurements (Carter & Heath 1990). The statistical measurements were made on the computer using the Excel 2007 and SPSS 17 program. For all the characteristics of the above athletes the following were measured: the average value (M) and standard deviation (SD). Differences in the age, training experience, in any anthropometric parameters and forms of the athlete's body type among the age groups were analyzed with the One Way ANOVA method for three groups (F-test) and 1 x 3 ANOVA (sex x age group) plan. Post-hoc-test followed, based on the theory of Bonferroni to examine significant changes observed among the age groups.

The correlations among the variables were examined with the Pearson's correlation coefficient (r). For each analysis, statistical significance was set at a probability level of a = 0.05.

Results

There was a statistically significant effect of the independent variable "Age Group" to the dependent one of "Years of Training" (Table 1), the three groups of the variable "Years of Training" were significantly different compared to age [F (2,18) = 6,499, p = 0.008 <0.05]. There was a statistically significant difference in the training years only between age groups A (12-13 years) and C (over 16 years).

Aggregated anthropometric characteristics of Alpine ski athletes in all three age groups are presented in Tables 2, 3 and in Figure 1. The "Index of lower limbs" showed long legs in all three age groups, while the "torso length ratio" showed a short torso for Group A (12-13 years), middle torso for Group B (14-15 years) and long torso for Group C (over 16 years old). The "pelvis – shoulder index" showed in all three age groups a large pelvis width.

Table 2. The aggregated features of the Alpine skiers according to age group: mean value (M) and standard deviation (SD) for somatometric parameters.

S/N	SOMATOMETRIC PARAMETERS	AGE GROUPS 12-13 y.o.		14-15 y.o.		16 ≥ y.o.				Bonferroni***
		M	SD	M	SD	M	SD	F(2,18)	p	Categories
1	Age (years)	12,6	0,55	14,7	0,49	17,6	1,88			
2	Training Experience (years)	4,4	1,34	7,9	2,85	10,6	3,78			
3	Body Mass (kg)	46,6	7,8	57,4	9,3	68,1	6	**11,192**	**0,01****	**b,c**
4	Body Height (cm)	158,4	3,2	167,9	4,4	176,9	8,1	**13,644**	**0,001****	**b, c**
5	Torso Length (cm)	43,8	1,8	49,1	2,9	54,8	3,7	**22,672**	**0,001****	**a,b,c**
6	Upper Limp Length (cm)	65,6	2,7	70,1	3,5	75	3,5	**9,138**	**0,002****	**b**
7	Lower Limp Length (cm)	92,2	4	99,6	2	99,1	6,8	**4,297**	**0,03***	**a,b**
8	Hips Perimeter (cm)	82,4	4,9	87,7	7,3	94,7	3,7	**7,894**	**0,003****	**b**
9	Waist Perimeter (cm)	74	8,5	73,4	8,1	74,7	7,4	**0,051**	**0,95**	
10	Thorax Perimeter (cm)	76,6	6,4	82,3	5,5	87,6	4,3	**7,538**	**0,004****	**b**
11	Arm Perimeter (cm)	23,4	2,8	23,8	1,7	26,4	2,4	3,781	0,043*	
12	Forearm–Cubitus Perimeter (cm)	22	1,2	23,3	1,7	25,4	1,6	**7,72**	**0,004****	**b,c**
13	Thigh – Femur Perimeter (cm)	42,4	0,5	43,7	5,3	48,6	3,3	**4,006**	**0,036***	**b**
14	Calf Perimeter (cm)	31,4	2,1	31,7	1,4	34,6	1,8	**5,497**	**0,014****	**b,c**
15	Knee Width (cm)	9	0,6	9,2	0,3	9,8	31,1	**3,736**	**0,044***	**b**
16	Hips - Coxa Width (cm)	26,4	1,1	28,7	2	32,2	1,8	**5,222**	**0,016***	**b**
17	Thorax Width (cm)	22,8	1,3	24,1	1,1	29	1,4	1,658	0,218	
18	Thorax Depth (cm)	15,8	3,3	16,9	1,7	17,9	1,2	1,994	0,165	
19	Shoulders Width (cm)	33	2,4	36,4	1,6	40,3	2,9	**15,978**	**0,001****	**b,c**
20	Elbow Width (cm)	6,8	0,4	7,4	0,6	8	0,6	**8,738**	**0,002****	**B**
21	Wrist Width (cm)	4,9	0,4	5,3	0,3	5,6	0,2	**9,025**	**0,002****	**B**
	Skin Folds Parameters									
22	Arm Biceps fold (mm)	5,5	2,7	4,14	2,1	4,56	1,8	0,566	0,577	
23	Arm Triceps fold (mm)	9,5	5,6	7,23	2,9	9,46	3,3	0,811	0,46	
24	Subscapular Fold(mm)	6,2	2,2	7,2	4,2	8,71	2,4	1,141	0,342	
25	Suprailiac Fold (mm)	10,8	8,5	8,2	5,8	10,63	4,8	0,384	0,686	
26	Shin Fold (mm)	7,2	2,7	6,7	1,3	6,6	1,3	0,18	0,837	
27	3 folds measurement SUM (21+22+23) mm	26,6	16,3	22,6	12,7	28,8	9,5	0,496	0,617	

****Note: Bonferroni Post –Hoc (Categories): **a:** 12-13 y.o., Vs 14-15 y.o., **b:** 12-13 y.o. Vs 16 < & above y.o., **c:** 14-15 y.o., Vs 16 < & above y.o., *p < 0,05, **p < 0,01*

Regarding the body composition indexes, the "body mass index (BMI)" in all three age groups showed a normal mass, while the "Ponderal Index" showed a corpulent type of Group A athletes (12-13 years). The other two groups had a slim type.

The "Waist-Hip Ratio (WHR)" showed increased fat allocation for Group A, while the other two groups were of perimeter type. Group C (16 over years old) had the highest average values of fat mass (5.29□2.36) and lean body weight (62.82□7.00), while Group A (12-13 years) had the highest average value of body fat (Table 3).

Table 3. The aggregated features of the Alpine skiers according to age group: mean value (M) and standard deviation (SD) for anthropometric parameters.

	Age Groups								Bonferroni***
	12-13 y.o.		**14-15** y.o.		**16** & above y.o.				
	M	SD	M	SD	M	SD	**F(2,18)**	**p**	**Categories**
Body Analogies Indexes									
Lower Limps Index	58,2	1,8	59,3	0,6	56,1	3,6	3,218	,064	
Torso Length Index	27,7	0,9	29,3	1,2	31,0	1,2	**13,640**	**0,00****	**b, c**
Pelvis – Shoulder Indexex	80.25	5.11	78.80	3.54	79.91	9.96	,069	,934	
Body Composition Indexes									
Body Mass Index (BMI-Kg/m²)	18,6	3,1	20,3	2,5	21,8	2,0	2,756	,090	
Leptosomic Index (cm/kg)	30,7	10,0	43,7	1,5	43,4	1,8	**5,051**	**0,018***	**b**
Fat Distribution Index (WHR)	0,9	0,1	0,8	0,1	0,8	0,1	**4,999**	**0,019***	**b**
Body Fat Idex (%BF)	7,82	5,58	5,53	2,82	7,71	3,26	,804	,463	
Fat Mass (FM) - kg	3,69	2,63	3,33	2,40	5,29	2,36	1,084	,359	
Lean Body Mass (LBM) - kg	43,31	2,71	54,10	7,48	62,82	7,00	**14,748**	**0,000****	**a, b**
Body Type Forms									
Endomorphism	2.50	1.77	2.07	1.34	2.83	1.06	,639	,540	
Mesomorphism	0.90	1.43	1.93	1.02	3.72	1.35	**8,849**	**0,002****	**b c**
Ectomorphism	1.40	2.01	3.36	1.07	3.17	1.06	3,701	0,045*	

****Note: Bonferroni Post –Hoc (Categories): **a:** 12-13 y.o., Vs 14-15 y.o., **b:** 12-13 y.o. Vs 16 < & above y.o., **c:** 14-15 y.o., Vs 16 < & above y.o., *p < 0,05, **p < 0,01*

Finally, the three forms of the athletes' body type the groups with the following mean values stood out: Group C (16 years old) for mesomorph (3.72±1.35), Group B (14-15 years) for ectomorph (3.36±0.07), while the Group A (12 to 13 years) in endomorph (2.50± 1.77).

There was a significant correlation (effect) between the age group and almost all anthropometric variables (Table 2, 3) with the exception of chest width, chest depth, waist perimeter and all skinfold parameters (Body Fat). Also, there was a significant correlation between the age group and the following body types: mesomorph type [F (2,18) = 8,849, p = 0,02 <0,05] and ectomorph type [F (2,18) = 3,701, p = 0.045 <0.05], with the exception of endomorph type. Note that there was a significant correlation between the age group and the dependent variable "torso length" [F (2,18) = 22,672, p = 0,001 <0,05], where there was a statistically significant difference between all categories (Table 2). "Bonferroni Post-Hoc Analysis" contributed to the above classification of the differences in the dependent variables (Table 2 & 3).

Table 4. The average values of the somatogram (x and y axis) of the Alpine ski athletes based on age.

Age Group					
12-13 years		**14-15** years		Over **16** years old	
x	y	x	y	x	y
-1,1	-2,1	1,29	-1,57	0,33	1,44

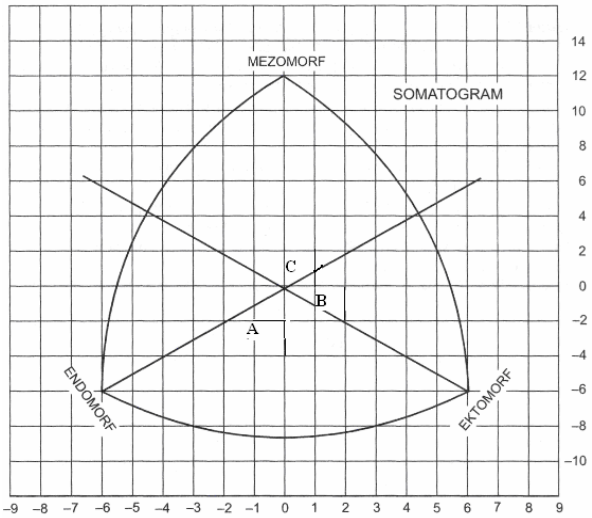

Fig. 1. The points of determination of the body type of the rated age group: A (12-13 years), B (14-15 years), C (16 years and older).

Discussion

The lack of substantial differences of Group A men (12-13 years old) in the majority of the anthropometric characteristics, must be taken into consideration in the selection of talent. As regards the body asymmetries, all three age groups have shown large lower limbs and large pelvis width. Also, the length of the torso was normal with respect to the age of the athletes. The indexes of the lower limbs and the torso length represented the skeletal index of the athletes. Group B (14-15 years) and C (over 16 years old) stood out, respectively.

Regarding the body composition indexes, the body mass index (BMI) in all three age groups was within the normal range, while the ponderal index presented the corpulent type of athletes.

The waist-hip ratio (WHR) showed increased breakdown of fat in the young age group, while the other two groups were of perimeter type. Finally, the body fat index (sum of 3 fat measurements), the ponderal index and the 5 somatometric parameters (Body Height, Elbow Width, Knee Width, Arm Perimeter, Tibia Perimeter) determined the athlete's body type. Where group C (16 years old) tended towards mesomorph, Group B (14-15 years) towards ectomorph, and group A (12-13 years) towards endomorph (Figure 1, Table 3 & 4). Also, there was a significant correlation between the age group and the following body types: mesomorph and ectomorph type, the endomorph type excluded. Similar results to this research are also shown by other researchers (Golab S. & Golab W. 1995).

Emeterio & González-Badillo (2010) studied the physical and anthropometric profile of teenage athletes in alpine skiing and their relation with the sports classification. Also, Högström et al. (2012) studied the anthropometric characteristics, body composition, body type and influence of the championship Alpine ski in teenagers of both sexes, while StÖggl et al. (2010) studied the influence of the championship in cross-country ski athletes.

Golab S. & Golab W. (1995) examining skiers of the World Winter Universiade in 1993 in Zakopane (Poland) suggested that athletes of Alpine ski were less slim based on the ratio of height and body mass (ponderal index) . They also had a greater percentage of fat compared with athletes of other winter sports and students (test group), that is, there were two equal groups with endomorph–mesomorph and ectomorph-mesomorph type. Female Alpine skiers were found with: narrow waist, small perimeter of the tibia, a large width of the bone base of the legs and higher percentage of fat, so mainly the mesomorph - endomorph type and endomorph - mesomorph type appeared. Sobiecki et al. (1996) studied the relation between somatometric characteristics and training volume of Polish national team athletes in cross-country skiing.

Durnin & Rahaman (1967) assessed the ratio of body fat to the lean body mass, which was calculated by subtracting the fat mass from the body mass. Also, Gurney & Jellife (1973) have proposed the following: the cross-section (CSA) of the muscles of the arms and legs without fat to be calculated based on an anthropometric formula, which integrates the limb and skinfold perimeter. Golab & Chrzanowska 2007 also show other modern methods of defining the body type, apart from Heath & Carter method, such as: Kretschmer method, Sheldon method, Wank method and Milicerowa method.

Conclusions

Based on the results of this study, it is concluded that the acquisition of information and data collection through an orderly and brief protocol for the somatometric measurements of Alpine skiers was an important tool to determine the body type, the profile and the talent of the athlete. The lack of substantive differences of Group A boys (12-13 years) compared to the teenagers and men in most anthropometric parameters must be taken into account in the selection of talents. As regards the asymmetries of the body, all three age groups have presented large lower limbs and large pelvis width. Also, the torso length was normal with respect to the age of the athletes.

The indexes of the legs and torso length represented the athletes' skeletal index, where Group B (14 to 15 years) and Group C (over 16 years old) stood out respectively. Regarding the body composition indicators the body mass index (BMI) in all three age groups was within the normal range, while the ponderal index showed a corpulent type of athletes.

The waist-hip ratio (WHR) had shown an increased fat allocation, in the group of younger ages, while the other two groups were of perimeter type. Group C (over 16 years old) tended towards mesomorph, Group B (14-15 years) to ectomorph, while Group A (12-13 years) to endomorph (Figure 1, Table 3 & 4). Also, there was a significant correlation between the age group and the following body type: mesomorph and ectomorph type, with the exception of endomorph type.

Based on the present paper, two hypotheses are proposed for future research. In the first case, the following question should be considered: "is it the athlete who chooses the sport or vice versa?", meaning, whether the anthropometric characteristics and their assessment are necessary to examine and foresee the talent and the athlete's performance in each sport. The second hypothesis concerns the question, "if the athlete's body type affects the athletic ability regardless of the training stimulus?

References

Carter, L., & Heath, B. (1990) *Somatotyping: development and applications*.Cambridge University Press, Vol. 5.

Chrzanowska, M. (1997). Cechy somatyczne i sprawnosc motoryczna meszczyzn z populacji Krakowskiej, [Somatic features and motor skills of men from the population Krakow]. *Academy of Physical Education im. Bronislawa Czecha in Krakow,* Studia i Monografie Nr 31.

Chrzanowska, M. (2004). Materialy do cwiczen z antropologii, [Materials for exercises in anthropology]. *Academy of Physical Education im. Bronislawa Czecha in Krakow*, Publisher scripting, Nr 56.

Durnin J., & Rahaman M. (1967).The assessment of the amount of fat in the human body from measurements of skinfold thickness. *British Journal of Nutrition*, 21.03: 681-689.

Emeterio, C., & González-Badillo, J. (2010).The physical and anthropometric profiles of adolescent alpine skiers and their relationship with sporting rank. *The Journal of Strength & Conditioning Research*, 24.4: 1007-1012.

Golab, S., & Chrzanowska, M. (1998). Przewodnik do cwiczen z antropologii [Exercise Guide anthropology]. Academy of Physical Education im. Bronislawa Czecha in Krakow. *Manuals and scripts Nr 2.*

Golab, S., Chrzanowska, M. (2007). Przewodnik do cwiczen z antropologii [Exercise Guide anthropology]. Academy of Physical Education im. Bronislawa Czecha in Krakow. *Manuals and scripts Nr 2, Third edition revised and supplemented.*

Golab, S., & Golab, W. (1995). Sylwetki somatyczne uczestnikow zimowej Uniwersjady 1993 [Silhouettes somatic Winter Universiade 1993 participants]. (Ed.) Uniwersjada 93 w badaniach naukowych. Zeszyty Naukowe AWF. [(E) 93 Universiade in research. *Scientific Journal of Academy Physical Education* in Krakow nr 72, 15-26.

Golab, W., & Golab, S. (2005). Charakterystyka morfologiczna zawodnikow snowboardu [Morphological characteristics snowboard athletes]. (W) Sporty zimowe, strategia rozwoju – badania naukowe. *Studia i Monografie [(Ed.) Winter sports, strategy development - research. Studies and Monographs]* nr 31, 107-113.

Gurney, J., & Jellife, D. (1973). Arm anthropometry in nutritional assessment: nomogram for rapid calculation of muscle circumference and crosssectional muscle and fat areas. *Am J Clin Nut,r* 26: 912-915.

Heath, J., & Carter, B. (1967). A modified somatotype method. *Am. J. of Physical Anthropology*, 27: 57-74.

Högström, GM., Pietilä, T., & Nordström P. (2012). A Body composition and performance: influence of sport and gender among adolescents. *The Journal of Strength & Conditioning Research,*2, 26 (7): 1799-1804.

Hymes, E.M., & Dickinson, A.L. (1980). Characteristics of elite male and female ski racers. *Medicine. Science. Sports Exercise,* 12 (3): 153-158.

Malousaris, G.G., Bergeles, N.K., Barzouka, K.G., Bayios, I.A., Nassis, G.P., & Koskolou, M.D. (2008). Somatotype, size and body composition of competitive female volleyball players. *Journal of Science and Medicine in Sport*, 11: 337—344.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2001). Φυσιολογία της άσκησης. Ιατρικές εκδόσεις Π.Χ. Πασχαλίδης, τόμος 2, Αθήνα [Exercise physiology. *Medical versions BC Pashalidis*, Volume 2, Athens],

Piechaczek, H. (1975). Oznaczenia calkowitego tluszczu ciala metodami densytometryczna antropometryczna. Materialy i Prace Antropometryczne, Wroclaw 89, [*Determination of the total fat body densitometry anthropometric methods. Anthropometric materials and works*. Wroclaw, 89].

Slaughter, M.A., Lohman, T.G., Boileau, R.A., Horswill, C.A., Stillman, R.J., Van Loan, M.D., & Bemben, D.A. (1988). Skinfold equation for estimation of body fatness in children and youth. *Hum. Biol.*, 60: 709-23.

Sobiecki, J., Szalkiewicz, A. Budowa ciala lyzwiarek i lyzwiazy szybkich ocenianych metoda Heath-Carter. (W.) (2005). Sporty zimowe, strategia rozwoju – badania naukowe. *Studia i Monografie, [Build skaters and ice skating evaluated Heath-Carter method. (Ed.) Winter sports, strategy development – research. Studies and Monographs]* nr 31, 115-120.

Sobiecki, J. (1994)Budowa ciala narciarzy klasycznych – czlonkow kadry Polski juniorow i seniorow. Zmiennosc biologiczna czlowieka, Vol.1. *Ogolnopolska konferencja naukowa: Czlowiek – Natura – Kultura.* Krakow: AWF, Uniwersytet Jagiellonski [Build classic skiers - Polish staff members of juniors and seniors. *Biological variability man, Vol.1. National Scientific Conference: Man - Nature - Culture*. Krakow: AWF, Jagiellonian University], 65-69.

Sobiecki, J., Golab, S., Krasicki, S., & Rosinski, J. (1996). Charakterystyka somatyczna i objetosc treningu zawodnikow kadry narodowej narciarstwa biegowego. *Warszawa, Wychowanie Fizyczne i Sport* [Characteristics of somatic and the volume of training athletes of the national team cross-country skiing. Warsaw, *Physical Education and Sport*], 4.

Stöggl, T., Enqvist, J., Müller, E., & Holmberg, H.Ch. (2010). Relationships between body composition, body dimensions, and peak speed in cross-country sprint skiing. Joutnal of Sports Sciences,28: (2), 161–169.

Tsolakis, C., Bogdanis, G., & Vagenas, G. (2006). Studies Anthropometric profile and limb asymmetries in young male and female fencers. *Journal of Human Movements*.50: 201-216.

Tsolakis, Ch,, & Vagenas, G.. (2010). Anthropometric, physiological and performance characteristics of elite and sub-elite fencers. *Journal of Human Kinetics*.; 23: 43-50.