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DIFFERENCES IN SOME ANTHROPOLOGICAL CHARACTERISTICS OF YOUNG ALPINE SKIERS RECORDED DURING ONE COMPETITIVE SEASON

RAZLIKE V NEKATERIH ANTROPOLOŠKIH ZNAČILNOSTIH MLADIH ALPSKIH SMUČARJEV SKOZI ENO TEKMOVALNO SEZONO

ABSTRACT

The aim of this investigation was to evaluate differences in the eleven tests used to determine anthropological characteristics, the one test used to determine physiological characteristics and the four tests used to evaluate explosive strength of young alpine skiers. Sixteen Croatian male alpine skiers participated in the investigation. Measurements were performed three times during one competitive season (at the beginning, during, and after the end of the season). Significant differences in anthropological characteristics that occurred between the three measurements were observed for body height (p=0.002), scapular (p=0.009) and abdominal skinfolds (p=0.002), bicristal (p=0.001) and bicondilar femur widths (p=0.029), femoral (p=0.009) and upper arm girths (p=0.002) and body weight (p=0.001). Furthermore, significant differences were observed for the continuous jump with bent legs for 15 seconds (p=0.05) (used to evaluate explosive strength). Among the motor abilities, explosive strength is known as most important success-related parameter in alpine skiing. According to the obtained results, it can be concluded that results in the continuous jump with bent legs for 15 seconds are the consequence of body adaptation to training. Despite children's constant growth, which continuously influences the results of the training process, the afore-mentioned test seems to be the best for evaluating current fitness levels in terms of explosive strength in young alpine skiers.

Key words: alpine skiing, school children, anthropological characteristics, explosive strength

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POVZETEK

Cilj raziskave je bil ugotoviti razlike v enajstih testih, ki jih uporabljamo za ugotavljanje antropoloških značilnosti, enega testa, s katerim ugotavljamo fiziološke značilnosti ter štiri teste, s katerimi ugotavljamo eksplozivno moč mladih alpskih smučarjev. V raziskavi je sodelovalo šestnajst mladih hrvaških alpskih smučarjev. V eni tekmovalni sezoni smo izvedli tri meritve (na začetku sezone, med sezono in ob koncu sezone). Značilne razlike v antropoloških značilnostih so bile zaznane v telesni višini (p=0.002), skapularni (p=0.009) in abdominalni kožni gubi (0.002) ter v bikristalni širini (p=0.001) in širini bikondilarnega femurja (p=0.029), obsegu stegna (p=0.009) in nadlahti (p=0.002), pa tudi v telesni teži (p=0.001). Značilne razlike so bile zaznane tudi v testu sonožnih poskokov v petnajstih sekundah (p=0.05), s katerimi smo ugotavljali eksplozivno moč. Med vsemi gibalnimi sposobnostmi je pri alpskem smučanju eksplozivna moč razumljena kot tista sposobnost, ki je najbolj povezana z uspešnostjo. Glede na dobljene rezultate bi lahko rekli, da so rezultati sonožnih poskokov v petnajstih sekundah posledica prilagajanja telesa treningu. Kljub nenehni rasti otrok, ki ves čas vpliva na rezultate trenažnega procesa, so se uporabljeni testi izkazali kot najboljši način ugotavljanja trenutnega stanja eksplozivne moči pri mladih alpskih smučarjih.

Ključne besede: alpsko smučanje, šolarji, antropološke značilnosti, eksplozivna moč

INTRODUCTION

The involvement of children from early ages in training and sport competitions on national and international levels raises interest in and the need for continuous monitoring of the impact that training has on young children and adolescents. This influence on younger age groups, in comparison to the adult population, is largely unknown, as children are in the process of physiological growth and development. Moreover, children have specific anthropological characteristics that contribute to success in different sports and lead to their further development into top level athletes. During children's growth, the influence of anthropological characteristics changes as well as their contribution to sport success; it is of utmost importance to continue monitoring and prevent possible negative influence on psycho-physical health (Naughton, Farpour-Lambert, Carison, Bradney & Van Praagh, 2000). This is only one of the reasons why it is important to understand the specifics of pediatric sports physiology (Matković, 1990; Rowland, 1996; Armstrong & Welsman, 2000; Malina, Bouchard & Oder, 2004). The aim of this investigation was to measure differences in specific anthropological characteristics and physiological and motor abilities in young alpine skiers during one competitive season.

METHODS

The investigation included 16 young male alpine skiers with a mean age of 13.94±2.01 years. They were 163.60±11.45 cm tall and weighted 57.47±15.71 kg. Participants in this investigation are members of Croatian ski clubs, continuously involved in training and alpine ski competitions. The frequencies of competitive season training for young alpine skiers are given in Table 1.

Table 1: Summary of the frequencies during one alpine skiing competitive season

	Hours of skiing trainings	Hours of fitness trainings	Number of races	Number of rest days
Frequencies	531	255	16	50

Measurements of anthropological and physiological characteristics and explosive strength were taken three times during the 2005/2006 competitive season, i.e. at the beginning of the alpine ski season, during the season and after the end of the season. The first measurement, performed before the preparation for the new competitive season (in May), gave insight into the level of training, of the chosen anthropological and physiological characteristics and of explosive strength. The second testing took place just before the season start (in November), after months of preparation, and gave insight into level of training after the preparative period. Finally, the third testing was done at the end of the season, and its function was to determine the influence of training on anthropological measurements of young alpine skiers (in March). The investigation included 11 tests to determine anthropological characteristics (body height and body weight, scapular skin fold, upper arm skin fold, abdominal skin fold, bicondilar femur width, biacromial width, bicristal width, femoral girth, upper arm girth, lower leg girth), one test for physiological characteristic (maximal oxygen uptake) and four tests to determine explosive strength (squat jump, counter movement jump, continuous jump with bent legs in 15 seconds, continuous jump with bent legs in 45 seconds). The anthropological characteristics used for the purposes of this investigation were determined according to the International Biological Program

(Mišigoj-Duraković, Matković & Medved, 1995). Maximal oxygen uptake was measured directly (COSMED), during a continuous progressive test on a treadmill. All four tests for explosive strength were done on a Kistler platform, connected to a computer. The performed jumps were analyzed with the Quattro Jump program. For the statistical analysis, ANOVA and T-test were used in the statistical package "SPSS for Windows". The level of significance was $p \leq 0.05$.

RESULTS

The changes of anthropological characteristics within the three measurements are given in Table 2.

Table 2: Results of variance analysis of the anthropological characteristics

Variables	Mean 1	Mean 2	Mean 3	SD	F test	p
WGH	161.1	163.4	166.3	11.9	7.52	**0.002**
SCS	7.17	7.98	8.2	1.32	5.56	**0.009**
SCT	9.69	10.21	10.74	2.25	1.97	0.16
ASC	7.66	9.61	9.56	2.38	8.25	**0.002**
BFW	9.15	9.21	9.47	0.81	4.03	**0.029**
BAW	35.17	35.8	36.41	3.45	1.38	0.27
BCW	24.83	25.95	26.71	1.88	9.6	**0.001**
FG	50.93	52.34	53.37	6	5.62	**0.009**
UAG	25.71	26.55	27.47	4.06	7.94	**0.002**
LLG	33.5	33.86	34.47	4.12	2.17	0.13
BW	53.73	57.12	60.49	16.1	8.45	**0.001**

Legend: body height (WGH), scapular skin fold (SCS), upper arm skin fold (SCT), abdominal skin fold (ASC), bicondilar femur width (BFW), biacromial width (BAW), bicristal width (BCW), femoral girth (FG), upper arm girth (UAG), lower leg girth (LLG), body weight (BW).

Statistically significant changes during a year of continuous training were observed in the anthropological characteristics of body height ($p=0.002$, Table 2), scapular skin fold ($p=0.009$), abdominal skin fold ($p=0.002$), bicondilar femur width ($p=0.029$), bicristal width ($p=0.001$), femoral girth ($p=0.009$), upper arm girth ($p=0.002$) and body weight ($p=0.001$). All the results of anthropological characteristics showed an increasing trend through the duration of the season, mostly reaching a peak at the end of the season (Table 2). In order to further differentiate between the measurements in which the significant changes occurred, a T-test was performed; the results are given in Table 3.

Table 3: Results of T-test for dependant samples for anthropological characteristics

Variables	t 1-2	t 2-3	T 1-3	p 1-2	p 2-3	p 1-3
WGH	-3.88	-2.07	-2.93	**0.001**	0.57	**0.01**
SCS	-3.18	-0.62	-3.02	**0.006**	0.55	**0.009**
ASC	-3.36	.09	-3.41	**0.04**	0.93	**0.004**
BFW	-.50	-2.20	-2.61	0.62	**0.045**	**0.021**
BCW	-2.17	-1.66	-4.04	**0.046**	0.12	**0.002**
FG	-3.86	-1.46	-3.86	**0.002**	0.17	**0.002**
UAG	-3.72	-2.02	-3.14	**0.002**	0.06	**0.007**
BW	-5.00	-1.96	-3.11	**0.000**	0.070	**0.008**

Legend: Body height (WGH), Scapular skin fold (SCS), Abdominal skin fold (ASC), Bicondilar femur width (BFW), Bicristal width (BCW), Femoral girth (FG), Upper arm girth (UAG), Body weight (BW).

Table 3 gives the results of T-test for differences in anthropological characteristics that occurred between first and second measurement (t 1-2), between second and third (t 2-3), and finally between first and third measurements (t 1-3). Table 4 gives the results of changes in tested physiological characteristics during one competitive year.

Table 4: Variance analysis result for test used to measure physiological characteristics

Variable	Mean 1	Mean 2	Mean 3	SD	F test	p
VO_2 max	2.90	3.25	2.93	1.04	0.98	0.40

Legend: VO_2max – Maximal oxygen uptake

The results are not statistically significant (p=0.4, Table 4). Changes in tested motor abilities are shown in Table 5.

Table 5: Variance analysis results for tests used to measure explosive strength

Variables	Mean 1	Mean 2	Mean 3	SD	F test	p
SJ	33.5	34.31	36.55	6.43	1.45	0.25
CMJ	31.59	33.03	34.94	5.12	1.82	0.18
CJ15S	28.41	30.39	32.87	6.16	3.40	**0.05**
CJ45S	24.94	25.33	29.47	5.43	2.17	0.14

Legend: Squat Jump (SJ), Counter Movement Jump (CMJ), Continuous Jump with bent legs (CJ15S), Continuous Jump with bent legs (CJ45S)

The results of the variance for tested explosive strength were statistically significant only in the test of a continuous jump with bent legs for 15 seconds (p=0.05, Table 5), while changes in other tests of explosive strength did not differ significantly. With respect to first measurement at the beginning of the study, the results obtained for the explosive strength had an increasing trend as the competitive season progressed (Table 5). A T-test was further performed for statistically significant test in order to determine the timing of the occurrence of significant changes.

Table 6: T-test results for dependant variables in the test of explosive strength

Variable	t 1-2	t 2-3	t 1-3	p 1-2	p 2-3	p 1-3
CJ15S	-1.72	-0.96	-2.81	0.11	0.35	**0.02**

Legend: CJ15S – Continuous Jump with bent legs

It is evident that statistically significant changes in the results of the test used to determine explosive strength occurred between the first and third measurement (p=0.02, Table 6).

DISCUSSION

Growth can best be comprehended as a process in which a person changes during a time frame according to chosen anthropological characteristics. The best predictors of biological maturation are anthropological characteristics growth and body weight; these were used for the purposes of this investigation. When figures of the speed of growth for boys aged 11 to 14 are taken into account, there are no statistically significant changes detected between the general population and participants of this investigation (Rowland, 1996, according to Tanner, Whitehouse & Takaishi). The mean growth of 4.79 cm detected in our participants during one competitive season is in concordance with the expected linear growth for boys of the same age group. Furthermore, the observed increases in body weight by 3.13 kg during this investigation are according to the estimation for boys of the same age. When the anthropological characteristics body height and body weight of our participants are compared to those characteristics of boy alpine skiers of the same age in the USA (Klika & Malina, 1997), it is evident that the boys of this study are 9.8 cm smaller and 6.3 kg lighter. Measured differences in skin folds which were less than 1 cm are difficult to observe in light of other anthropological characteristics. It seems that skin folds change in their own time, without following the joint pattern of other anthropological characteristics (Matković, 1990). Of all the skin folds measured, only the abdominal skin fold is under the external influence and can be used to reflect the central fat content. As a result, it can be expected to be the largest at the first measurement and then to decrease between further measurements, as the training process intensifies.

Our results do not follow the previously mentioned pattern while the greatest result was detected after preparations for the competitive season, i.e. just before the start of the season. This can probably be explained by the lack of aerobic training during this period, which was also observed by Axtella and his coworkers (1997). The observed growth of acromial, bicristal and bicondilar femur widths is expected and follows the general linear growth pattern for the boys of that age (Armstrong & Welsman, 2000). Growth trends were unsurprisingly observed for the three measured girths (upper arm, upper and lower leg); this can be attributed to the extensive training process, which exerts a positive effect on the musculature. The mean duration of an alpine ski run is approximately one minute in technical disciplines and only about two minutes in speed disciplines. Nevertheless, for success in alpine skiing, one must also work on aerobic capacities in order to improve one's wellbeing in a relatively hypoxic environment due to the higher altitude in which the training and competitions takes place, as well as to speed up the recovery process after using the anaerobic power needed during alpine ski races (Bosco, 1997, Hartman, Mader, Niessen, Spitzenpfeil & Lehnen, 2005).

Our results show that maximal levels of aerobic capacities of 3.25 L/min. were achieved just before the competitive season start, while LeMura and his coworkers detected higher levels of aerobic capacities (4.03 L/min.) for alpine skiers aged 16.7 years. According to Rowland, the highest velocity of absolute VO2 max growth (0.412 L/min.) for boys is expected around puberty, and occurs at the point of maximal growth (around 14.3 years). Moreover, the growth of VO2 max is in positive correlation with skeletal maturation and body weight, and the previously mentioned positive correlation is even more pronounced in child athletes with greater muscle proportion. If we take into account the age of boys from our investigation, who are 2.8 years younger than boys from LeMura's investigation, and the expected VO2 max growth of 1.15 L/min. per year, it could be expected that the boys in this study would have even better developed aerobic capacity. When the results of VO2 max (3.03 L/min.) for the participants in our investigation are compared to older alpine skiers with a mean age of 15.93 years (3.86 L/min.), from the investigation performed by Matković and coworkers in 1994, it is evident that results in our investigation are lower by 0.83 L/min. Yet again, when expected yearly growth of VO2 max of 0.412 L/min. (according to Rowland, 1996) is accounted for, then the expected results for our participants reaching the age of 15-16 years would be 3.44 L/min., which is still 0.42 L/min. lower.

Previous investigations showed that the development of explosive strength through different high and long jumps has a positive impact on alpine ski achievement (Reid & Johnson, 1997; Žvan & Lešnik, 2000). In this investigation, the only statistically significant changes were determined in the continuous jump test with bent legs for 15 seconds. This can probably be attributed to the relative psychological immaturity of our participants, leading to lack of motivation for other, more demanding tests such as continuous vertical jumps in 45 seconds. The importance of explosive strength is evident throughout the whole alpine ski race, starting from the beginning, when the skier bursts through the starting gate. It remains to be determined how the anthropological characteristics influence success in alpine ski races, and if there is a correlation with specific characteristics and future successful alpine skiers. The presumption is that growth of investigated anthropological characteristics through the senior categories will be similar to values of top level alpine skiers (Neumayr, Hoertnagl, Pfister, Koller, Eibl & Raas, 2003), while there was a high positive correlation between analyzed anthropological characteristics and success in alpine skiing (Hartman, Mader, Niessen, Spitzenpfeil & Lehnen, 2005).

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