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Original Article

Model Characteristics of Morphological Indicators of the Body Composition of Ski Nordic Skier: Case Study

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Abstract

The current study analyzed the This usually involves continuous individual modeling and analysis of morphological parameters and body composition of the male Ski biathlete (A.V), a member of Ski Club "Romanija" Pale, and the Junior BIH national team. The goal of the work was to analyze and determine the characteristics of the morphological model and the competitors' body structure. For the purposes of the study, 39 parameters were measured, which defined the space of morphological dimensions, Kettle Index (g/cm), and Relative body height and body mass index, and Body Composition. The analysis of the results showed that the model characteristics of morphological parameters and body composition of our subject are in the range of very good biathletes. The obtained results confirmed the presence of the ectomorphic - mesomorphic somatotype, which creates optimal prerequisites for an individual approach to the training process and achieving a differentiated impact when improving the technique of biathlete skiers

1. Introduction

Ski sports, including biathlon, is a sport with a significant participation of the motor-functional abilities of athletes. Timely detection of morphological status is an important and necessary imperative during training and competition. This usually involves continuous individual modeling and analysis of morphological parameters and body structure. Using the anthropometric method, we assess Body composition (BC) and determine the dimensionality of the skeleton, which helps predict individual or combined parameters in defining BC, energy consumption, total and segmental redistribution within the organism (Pavlović, & Kozina, 2022).

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Top sport represents a specific field of activity that aims to achieve high top results. Most anthropological research points to the heterogeneity of the physical status of athletes in different sports (Bunc, Vávra & Levora, 2005; Podrigalo, Galaško & Lozovoj, 2007; Âgello & Krušenskij, 2008, Curțianu, Turcu, Alexe, Alexe, & Tohanen, 2022, Čaušević, Rani, Gasibat, Čović, Alexe, …, & Alexe, 2023). In different sports, morphological differences affect the results of competitive activities in different ways (Chepulėnas, 2006; Chepulenas, Kochergina, & Statatkeviciene, 2011, Trybulski, Makar, Alexe, Stanciu, Piwowar, …, & Krzysztofik, 2022a), while the specificity of the sport or discipline also affects the changes and manifestation of BC index in the context of impact on performance (Larson, Henriksson, & Larsén, 2008; Psotta, Sviráková, Bunc, Šeflová, Hrásky, & Martin, 2009). Ski biathlon unites cross-country skiing with challenging stages shooting from a rifle. In most cases, the result is subordinate to the achieved speed of the biathlete on the track, his accuracy of shooting with a fixed target rifle and the time it takes to hit the target, depending on the position in which the competitor is. (Luchsinger, Talsnes, Kocbach, & Sandbakk, 2019, Lunghi, Brocherie, & Millet, 2019, Luchsinger, Kocbach, Ettema, & Sandbakk, 2020). The shooting part of the biathlon largely depends on the previous emotional state of the competitor, current weather conditions during shooting and running on the track, as well as other specifics related to the snow surface, dynamic and static balance of the competitor on the track and his coordination. According to Forbes, Chen, & Blouin (2018) body balance is one of the most important prerequisites for high-quality and successful target shooting. The high intensity that is present during running, and immediately before shooting, significantly affects the locomotor stability of the competitor's body in shooting from a standing position, which has a negative effect on the competitor's body oscillations. This effect could be due to the tension that certain muscles are subjected to during movement (Trybulski, Wojdala, Alexe, Komarek, Aschenbrenner, … & Krzysztofik, 2022b). Any disturbance of the balance of the body is significantly correlated with the good stability of the execution of the movements which are transmitted to the rifle by the muscular kinetic chain. This is the most common reason for the present differences, i.e. shooters with good and bad shooting results on the range (Köykkä, Laaksonen, Ihalainen, Ruotsalainen, & Linnamo, 2022).

Biathlon as an endurance sport integrates downhill, ascent and flat skiing during the race. During biathlon running, the musculature of the cranial and caudal regions is engaged, thus the optimal body size and BC specific to the sport are necessary to maximize athletic performance (Sandbakk, & Holmberg, 2014). However, within the biathlon sport, some physiological variations have been observed, which are mostly subordinated to the body weight of the competitors. The conclusion is that skiers with a higher body mass are faster on all terrain configurations, except on steep slopes, in contrast to skiers with a lower body mass who have an advantage on steep slopes. World-class combined skiers have significantly better motor, physiological and functional parameters compared to national level athletes (Holmberg, Roshdal & Svedenhag, 2007; Sandbakk,

Holmberg, Leirdal, & Ettema, 2011; McGawley & Holmberg, 2014; Akay, About, Özçiloglu, & Heil, 2014; Danielsen, Sandbakk, McGhie, & Ettema, 2018).

Certainly, the long-term training period of elite biathletes is significantly correlated with the definition and prediction of the optimal age limit in order to determine individual sports results of the highest level. In addition to physiological-motor parameters, important factors that define the athletic condition of competitors are morphological characteristics and parameters of motor-physical status (Kochergina, & Chepulenas, 2012). In the sport of biathlon, the efficiency of the competitor is subordinated to his speed of sliding on the track, accuracy and speed of shooting from the rifle (Cholewa, Gerasimuk, Szepelawy, & Zajac, 2005). Exceptional technique, aerobic-anaerobic potential of the competitor, his age and the length of the training and competition process influence top sports performances in all sports, including biathlon (Preobrazhentsev, 2007; Carlson, 2011). On long tracks, performances such as technique and speed of cross-country skiing depend to a large extent on BC index (Mahood, Kenefick, Kertzer, & Guinn, 2001), while rifle shooting results are usually subordinated to the athlete's mental condition, adequate shooting technique, long-term sports experience and age competitors (Manfredini, Manfredini, Carrabre, Litmanen, Zhukovskaja, …, & Haberstroh, 2002; Cholewa et al., 2005; Vickers & Williams, 2007). The most common are functional parameters, which define the Index of physical work capacity and physical functions in a significantly high correlation with the ratio of body mass of biathletes and their components (Bunc et al., 2005; Psotta et al., 2009; Ryabov, Ryabova, Zebzeev, & Chumakov, 2023). Research indicates that BC is the most important anthropometric indicator in cross-country skiers and biathletes. Cross-country skiers have an ectomorphic mesomorphic somatotype, while female skiers have an endomorphic mesomorphic type. Ski biathlon mainly focuses on the preseason preparation period using cyclical activities (running, rollerblading, cycling, swimming, etc.) exercises for the development of endurance and strength (Pavlović, Milivojevic, & Gerdijan, 2022).

In order to enable today's top sport to provide a high-quality, timely and objective evaluation of the athlete's sports form and, in this connection, possibly make corrections in the plan and program of the training process, all in accordance with the principles of individuality, the specifics of the sports branch, adequate model characteristics are increasingly used (Zebzeev & Zdanovich, 2016). Some authors (Aminov & Razyapov, 2010; Koryagina & Matuk, 2010; Ryabov et al., 2023) point out that adequate anthropological dimensions significantly influence the forecast of sports results. They are correlated with the quality of physical performance as well as the body's reaction to various training loads and technical manifestations, especially in athletes under stress. Defining certain parameters of the sports model, it is important to keep records of anthropometric indicators and BC, which allows for a concise and clearly differentiated approach when it comes to athlete selection and individuality during the training cycle.

Physical preparation is important in ski biathlon and is an indispensable segment in the overall anthropological profile of every athlete. According to the

available information, no special research has been done in Bosnia and Herzegovina that studies and detects the anthropological model of biathletes in any level of competition.

2. Material and methods

Therefore, the basic goal of the research was to detect, analyze and define the anthropological model, including the BC of the male biathlete.

Research hypothesis

The applied parameters of anthropological dimensions will define adequate model characteristics and confirm the appropriate somatotype of a biathlon skier.

2.1 Participants

A cross-selection study was conducted with biathlete Aleksa Vuković (A.V), 22 years old (Body height 193cm; Body weight=85.80kg; BMI=23kg/m^2; Heart pulse=44bpm, saturation O_2=97.8%; VO_2max average=77ml/kg/min; %HRmax=86.28). A member Ski Club "Romanija" Pale, and the BIH national team since 2019. Several times state champion of BIH in biathlon and twice winner of the Biathlon Balkan Cup.

2.2 Sample of variables

The total of 21 variables were variables of anthropometric space which primarily referred to longitudinal, circular and body mass dimensions and skin folds' dimensions, Kettle Index (g/cm), and Relative Body Height and Body Mass Index [height- (body weight +100)] and 18 variables of BC.

2.3 Testing Protocol

The measurements of the morphological space were carried out according to the ISAK methodology. Standard metric instruments were used: Stadiometer - used to measure body height (SECA 206, Seca Corporation, Germany); flexible tape used to measure the perimeter of the body and its segments; Body weight and BC were assessed by the bioelectrical impedance method using a Body Composition analyzer (Tanita Inner ScanV BC 545N, Tokyo, Japan). Digital caliper for measuring skin folds (HERGOM-model BF02FITH, Italy) and digital caliper for measuring transversality diameter (Mitutoyo, Japan). Anthropometric measurements were performed in April 2024 and were in accordance with the procedures of the Declaration of Helsinki.

3. Results and Discussions

Athlete profiling and selection defines a narrowly designed and concise analysis of morphological dimensions and physical status, in order to define an adequate athlete model based on adequate detection, analysis and projected performances. Often, the identification of sports talent, or the orientation of athletes in accordance with its parameters for the respective disciplines, depends on the identification of relatively independent characteristics that are compared with the reference data of the best competitors in a certain sport (Pavlović, Vrcić, Simeonov, Radulović, & Gutić, 2021).

The aim of the research was to detect, analyze and define the entire anthropological space, taking into account the BC of the male biathlete. The obtained numerical values of the parameters of our competitor indicate adequate morphological dimensions and body structure, which are mostly present in elite competitors, the so-called model of biathletes and Nordic skiers.

Table 1. *Measured parameters Ski biathlete*

	Anthropometrics Characteristics	Values	Body Composition (BC)	Values
Dimensionality and voluminousness body	Body height (cm)	193	Body fat mass (%)	8.7
	Kettle Index (g/cm)	444.559	Body water (%)	65.7
	Body mass index (BMI kg/m²)	23	Body muscle (kg)	74.5
	Relative body height and BMI [height- (body weight+100)] in relative units	7.2	Basal metabolism (kCal)	2309
	Body weight (kg)	85.8	Daily calorie intake - DCI (kCal)	9661
	Chest perimeter (cm)	102	Metabolic years	12
	Upper arm permeter (cm)	33	Visceral fat	1
	Forearm perimeter (cm)	28.5	Bones (kg)	3.8
	Abdomen perimeter (cm)	80	Segmental values of Body muscles (kg) & Body fat (%) Right hand muscle (kg)	5.1
	Upper leg perimeter (cm)	58	Left hand muscle (kg)	5
	Lower leg perimeter (cm)	36	Torso muscle (kg)	39.9
	Wrist diameter (cm)	5.7	Right leg muscle (kg)	12.2
	Knee joint diameter (cm)	11.7	Left leg muscle (kg)	12.3
Skin folds	Chest skin fold (mm)	3.2	Right hand fat (%)	5.6
	Triceps skin fold (mm)	5.6	Left hand fat (%)	6.7
	Biceps skin fold (mm)	2.6	Torso fat (%)	8.5
	Subscapular skin fold (mm)	8.1	Right leg fat (%)	10.1
	Suprailiac skin fold (mm)	5.8	Left leg fat (%)	10
	Abdomen skin fold (mm)	6		
	Front thigh skin fold (mm)	5.5		
	Rear thigh skin fold (mm)	10		

The results contained in the Table 1. are significant from the aspect of modeling athletes, in our case the ski biathlon, so in all analyzes the specific individual context of the interpretation of the results must be taken into account. According to Vernillo et al. (2013) the anthropometric profile of a male or female athlete is significantly positioned in defining the potential for performance success in a discipline. Certainly, specific anthropometric profiles together with physical status are necessary for the best sports performance in a discipline. The results of our competitor numerically and somatotypically define an adequate ectomorphic-mesomorphic status of a biathlete, with an average height (193 cm), weight (85.8 kg), BMI (23 kg/m2), Kettle index (444.559) and relative body weight. The height-mass index (7.2) are clear indicators of the dominance of primary longitudinality over body mass, which is numerically higher than the results obtained in previous studies (Psotta et al., 2009; Papadopoulou et al., 2012; Ryabov et al., 2023).

The parameters of transversality, body mass and voluminousness of a biathlete (A.V) adequately represent the morphological space and, together with longitudinality, significantly determine the ectomorphic-mesomorphic somatotype of anthropological dimensions, of top skier, which is important when performing cross-country skiing technique and is a determinant of success (Hebert-Losier, Zinner, Platt, Stoggl, & Holmberg, 2017; Sandbakk & Holmberg 2017; Zoppirolli, Modena, Fornasiero, Bortolan, Skafidas, Savoldelli, …, & Pellegrini, 2020).

By looking at the relationship between chest circumference in relation to the circumference of the abdomen (Table 1), it can be concluded that the meso-ectomorphic somatotype of our competitor is present. Also, the relationship between the circumference of the cranial and caudal extremities defines the appropriate proportion, which is explained by the considerable presence of strength as a prerequisite for the manifestation of maximum performance (Sandbakk, et al. 2014; Pavlović, et al. 2022). In biathlon running, the total body weight shows a high correlation with the result success, while the muscle mass of the arms has a negative correlation, especially when moving uphill. It is the values of body circumference and mass in addition to muscle mass that are most often seen as good predictors of results in biathlon running, which extracted in our study, which are in accordance with the findings (Larsson, Henriksson-Larsén, 2008). Current study shows a low percentage of fat, below 10%, with a higher percentage of muscle mass, which defines close to 90% of the total body weight of runners, while significant variations in energy consumption are also achieved by changes in the mode of activity and significant longitudinality.

The sum of skinfold values is lower than the results (Muñoz, Muros, Belmonte, & Zabala, 2020), which is a reliable indicator of a good anthropometric structure. Stöggl, Enqvist, Muller, & Holmberger, (2010) confirms the independence of the running technique of biathletes in relation to body height, while body mass, BMI, muscle mass of the arms and shoulder girdle, as well as a lower percentage of fat, were directly correlated. It is recommended that cross-country skiers should strive to achieve a BC with a high degree of muscle mass and a lower fat%, which was practically identified in our study (Table 1) supporting previous studies (Kochergina & Chepulenas, 2012, Ryabov et al., 2023). Body water (65.7%) and body muscles (74.5 kg) are high values, which supports the fact that this is a quality ski racer, given the fact that the presence of water in the muscles indicates good hydration and muscle functioning.

Recorded segmental values of BC of topological regions are quantitatively and qualitatively positive values that contribute to a clearer and better model structure. The muscle mass participates with close to 88% of the total body mass and the participation of the bone mass (3.8 kg), which is an indicator of mineralization and bone structure. The segmental physical status of our competitor (Table 1) records the dominance of trunk muscle mass (40kg), followed by identical values of the lower extremities (left leg 12.3kg vs. right leg 12.2kg) and upper extremities (left arm 5kg vs. right arm 5.1kg) which is an indicator of the topological harmonic development of voluminousness. In the total amount of body fat (8.7%), the cranial extremities

occupy the smallest percentage (left arm 6.7% vs. right arm 5.6%), followed by the trunk (8.5%) and a slightly higher percentage by the caudal extremities respectively (left leg 10% vs. right leg 10.1%). An inverse segmental relationship between muscle mass (kg) and fat tissue (%) is evident, with an emphasis on the trunk area, and then on the extremities.

According Pavlović & Kozina (2022) as much as about 50% of body fat is found in the subcutaneous area, which provides information on local depots and fat distribution in BC, which are significant. In our study, there is an inverse relationship between muscle and fat component percentage and a higher percentage of water, which is significant in ski biathlon, especially from the aspect of an individual approach in the training process and a potential runner model. The obtained results of study are in accordance with the findings of some studies (Oguri, Zhao, Du, & Kato, 2004; Arrese & Ostariz, 2006) which analyzed the internal balance of the presence of muscle and fat, as well as the unfavorable influence of skinfold thickness on the realization of motor performance, based on the thesis that always a low value relative fat is favorable in mechanical and metabolic aspects physical activity (Stöggl, Muller, & Stöggl, 2015). High demands during physical activity also define adequate nutrition, which is very important for the competitor's endurance and performance in biathlon skiing. Only with adequate and proper nutrition, good sleep and rest can the regeneration of hormonal loss, functions of the nervous system, energy reserves and the amount of water in the body (dehydration) and electrolyte transfer be achieved. Very often, inadequate intake of energy and nutrients in cross-country skiing puts athletes with increased nutritional deficiencies, which can jeopardize their sports parameters. In this regard, the biathlete's basal metabolism is 2309 kCal, while DCI is 9661 kCal, which are good parameters that indicate differences compared to similar studies (Papadopoulou, Gouvianaki, Grammatikopoulou, Maraki, Pagkalos, Malliaropoulos, …, & Maffulli, 2012), which is a guarantee of good sports activity. Based on a complete analysis of all measured physical status parameters, our subject corresponds to the biological metabolic age of a younger school-age child, which is significantly less than his biological age and is a good indicator of current athletic form and general health status.

Considering the potential of our competitor's functional abilities (VO_2max=77ml/kg/min and %HRmax =86.28), it can be said that it is in line with most of the results of top adult skiers, which are influenced by age, anthropometric characteristics and BC. According to (Hebert-Losier et al., 2017; Sandbakk & Holmberg, 2017; Losnegard, 2019; Zoppirolli et al., 2020) the VO_2max parameters of the best female competitors are about 80 ml/kg/min and about 90 ml/kg/min for males, with pronounced upper limb strength and exceptional skiing technique, which is also evident for our ski biathlete. Also, according to current norms, A.V belongs to the Superior category, which was confirmed in some earlier similar studies (Pavlović, Mihajlović, Radulović, & Gutić, 2021).

What was extracted as a result and is significant in the energy balance of the organism is the state of hydration of the organism A.V (water %) and the

replenishment of essential electrolytes, which also contributes to the distribution of the results of current measurements, especially BC, supporting research (Southard & Pugh, 2004), while aerobic a component with BC and an appropriate morphological profile of key elements for good performance in long-duration activities (Joyner & Coyle, 2008; Chepulenas, et al. 2011).

Generally in elite sport, exercise physiology is focused on finding a model to better control the training process, adjusting it on periodic individual evaluations that can improve physical fitness and aerobic power. Energy capacities and their economy during activity are basic parameters of motor-functional performance and are in direct correlation with morphological and physiological consumption. Energy power and economy of work are the main parameters of motor performance, they are direct correlation with the morphological and physiological profile of athletes, their characteristics and the level of the muscle training process. The economic efficiency of physical activity directly corresponds to the athlete's biomechanical qualities and mainly depends on his anthropometric characteristics and their build and adopted movement patterns.

4. Conclusions

The study indicated that the development of applied model representations of morphological dimensions and BC in significance of analytical and prognostic training work in the sphere of individual approach, in this case of ski biathlon. After determining the characteristics of the model, it became possible to compare the actual indicators of the biathlon skier's body structure with other athletes or competitors from the area of Nordic skiing and draw appropriate conclusions. This will allow us to observe and analyze the deviation of each BC indicator from the ideal model and direct further work towards solving the detected problem.

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