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FITNESS PROFILE OF SKI BIATLON COMPETITOR ALEKSA VUKOVIĆ: CASE STUDY

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ABSTRACT

Today's top sport requires high performance from competitors. Ski biathlon is in the category of sports that requires an adequate morphological profile and body composition of athletes. In order to achieve a good placement, the integrated participation of all motor skills of the athlete is extremely important, which, along with good technique, is a predictor of a good result. In this regard, top ski biathletes define an adequate morphological profile, body composition and high-performance motor skills (the so-called fitness profile). The current study analyzes the motor (fitness) profile of Aleksa Vuković (A.V), ski biathlete, competitor of SC "Romanija" (Pale) and member of the BIH national team, since 2019.
Keywords: *Fitness profile, motor skills, ski biathlon, detection, evaluation.*

1. INTRODUCTION

Cross-country (XC) skiing and biathlon are similar endurance sports in which competitors ski on different sections, on different terrains, with exceptional performance related to skating and skiing. XC skiing involves continuous skiing from start to finish, biathlon skiing is punctuated by breaks on the range during the competition. Biathletes also use exclusively skating technique, while in XC skiing competitions skating or classical techniques are used (Myakinchenko et al. 2022). Biathletes must ski with a rifle, combining their XC ski training with shooting as a whole competition, not just XC skiing, while XC skiers don't have to. The need of biathletes to include shooting in the training process, as well as the preparation for rifle skiing, should probably have a negative effect on the training load profiles of biathletes (Luchsinger, et al., 2018). Competition success is influenced not only by subjective factors (physical fitness, technique, psychology and tactics), but also by objective factors (conditions at the competition site, temperature and altitude during the competition). Ski biathlon combines cross-country skiing and rifle shooting, the result of which is subordinate to the speed of skiing, the accuracy of shooting, and the time interval for which the target is hit in a standing or lying position (Luchsinger et al., 2019; Lunghi, Brocherie, & Millet, 2019; Josefsson, et al., 2021; Luchsinger, et al., 2020). The shooting part of biathlon is primarily determined by previous intensity during skiing, shooting time, changes in weather conditions and many specifics that include the surface and balance, i.e. posture on skis.
According to Forbes, Chen, Blouin (2018) consider the balance of the upright body to be one of the most important factors of successful shooting, because intensive skiing before shooting affects the stability of the body when shooting from a standing position, which affects the oscillation of the body during shooting. Impaired body balance is closely related to the

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stability of movements transmitted to the rifle, and is closely related to shooting accuracy. On the basis of why we distinguish shooters with good and bad results of precision, i.e. shooting (Köykkä et al. 2022). The difference between the shooting conditions of biathlon and other shooting sports is that the athletes are obliged to shoot with great physical fatigue after sliding a certain distance along the prescribed line.

In the competitive activity of cross-country skiing, upper and lower body muscles are used, so optimal body size and sport-specific body composition are necessary to maximize sports performance (Sandbakk & Holmberg, 2014). World-class combined skiers have higher maximal oxygen consumption, superior anaerobic power, muscular endurance and strength compared to national-level athletes (Holmberg, Roshdal, Svedenhag, 2007; Sandbakk et al., 2011; McGawley et al., 2014; Akay et al., 2016; Danielsen, et al., 2018).

The multi-year training process of elite biathletes is closely related to the prediction of the optimal age limit in order to seek individual sports results of the highest level. In addition to physiological parameters, factors that characterize the sports condition of biathletes include anthropometric parameters and parameters of physical (fitness) status (Kochergina & Chepulenas, 2012). In the sport of biathlon, mastery depends on sliding speed, accurate and rapid shooting (Cholewa, et al., 2005). High sports mastery is influenced by athletic and technical preparation, functional ability, competitor's age and years of sports experience (Preobrazencev, 2007; Carlson, 2011; Lee, Yoon, & Seo, 2017; Laaksonen, et al. 2020). Skiing technique and sliding speed on long tracks depend on the body composition index, while shooting results are subordinated to the athlete's mental readiness, shooting technique, sports experience and competitor's age (Manfredini, Manfredini, Carrabre, et al., 2002; Vickers & Williams, 2007). Indices of physical work ability and physical function of biathletes are related to body mass ratio and their components (Bunc, Vavra, Levora, 2005; Psotta, et al., 2009).

The use of model characteristics in top sports enables a timely and objective assessment of the athlete's condition and the introduction of corrective changes in the sports training plan due to the targeted implementation of the principle of individual approach, respecting the specifics of sports activity (Zebzeev & Zdanovich, 2016). In addition to the adequate physical status of the athlete, the motor fitness profile of the biathlete is also very important. Physical preparation is important in ski biathlon and is an indispensable segment in the overall anthropological sports profile. A top biathlete must possess a high level of development of all motor skills (speed, strength, coordination, flexibility, balance, precision) and functional skills (endurance) that they develop during training and partly during competition (Myakinchenko, Heil, Kriuchkov et al. 2022). Most of today's biathletes suggest improving the competitor's anaerobic metabolism as the main content of training (Wang, 2023). However, it is well known that skiing speed has a greater influence on biathlon performance than shooting accuracy and speed (Laaskonen, Finkenzeller, Holmberg et al. 2018a).

How important is physical preparation is shown by the data of the study (Schmitt, Bouthiaux, Eleven, (2020), which, observing the changes during ten years of successful male biathletes, confirmed a significant increase in the annual volume of training from some 530 to 700 hours per year and a large polarization in the distribution of training intensity that defined the fitness abilities of biathletes.

Physical preparation (motor fitness) is an indispensable link in ski biathlon and is an indispensable segment in the overall anthropological sports profile. According to available information, there are no specific studies in Bosnia and Herzegovina (BIH) that analyze individual motor and functional parameters of biathletes. The goal of the research was to determine and analyze the motor fitness profile of BIH competitor (A.V).

2. METHODS AND MATERIALS

2.1 Participants and Sample Variables

The study was conducted with BIH biathlete Aleksa Vuković (A.V), 22 years old (Height 193cm; Weight 85.80kg; BMI 23kg/m2; Body fat 8,7%; Body water 65,7%; Body muscle 74,5kg; Heart pulse 44bpm; Saturation O_2 97.8%; VO2max 77ml/kg/min; %HRmax 86.28). A member Ski Club "Romanija" Pale, and the BIH national team since 2019. Several times state champion of Bosnia and Herzegovina in biathlon and twice winner of the Biathlon Balkan Cup. A total of 38 variables were variables of evaluation Physical fitness profile (Table 1).

2.2 Experimental Design

The HGS of the was measured by the method of isometric digital dynamometry (CAMRY-EH101, USA). To estimate arm speed the subject threw the handball ball from a difference distance with the dominant right hand. The speed of movement of the ball was measured by the Velocity Speed Radar Gun-Bushnell (model 101911, USA). All variables applied to the assessment of fitness profile according to (Mackenzie, 2005). Participant A.V provided oral informed consent prior to testing. All measurements were conducted during the month of April 2024., in accordance with the procedures of the Declaration of Helsinki.

3. RESULTS

The main goal of the research was to analyze the motoric profile of ski biathlete A.V, a member of SK “Romanija” Pale (BIH). Biathlon as a sport integrates a greater number of motor skills. Specific physical characteristics (fitness), profile are required for the highest levels of performance in every biathlon discipline (speed, sprint, strength, endurance, flexibility, agility, etc.). In order for a biathlete to adopt, improve and automate everything necessary in the technique of running and shooting, he must have adequate, well-conceived and directed training. However, above all, the competitor must have an adequate morphological, motoric and functional profile. It was our study that defined an adequate motor-functional profile of our biathlete. Biathlon is a complex Olympic winter sport that consists of cross-country skiing and rifle shooting, where motor, physiological, biomechanical, and psychophysiological factors are extremely important and influence the final ranking of competitors (Stöggl, Bishop, Höök, et al. 2015; Laaksonen, Jonsson, Holmberg, 2018b; Björklund, & Laaksonen (2022). Some authors (Aminov, & Razyapov, 2010; Koryagina & Matuk, 2010; Ryabov, et al., 2023) suggest that model characteristics of athletes have a great influence on sports results, the dominance of certain physical qualities of athletes. It is this study and the achieved results that confirm previous research.

Table 1: Measured parameters Ski biathlete

			Results
PARAMETERS OF FITNESS PROFILE	1.	Push-ups test (20")	23
	2.	Sit-ups test (30")	21
	3.	Pull-ups test (60")	20
	4.	Squats test (60")	54
	5.	Standing broad jump test (cm)	260
	6.	Triple jump standing (cm)	761
	7.	Five jumps standing (m)	12.93

	8.	Sitting forward bend (cm) - sit & reach test	31
	9.	Supine position in back, one leg raise (in sagital plane)	Right leg -132° vs. Left leg-131°
	10.	Supine position in back, both leg raise and spread (in frontal plane)	132. 40°
	11.	Tapping hand 20"	46
	12.	Tapping leg 20"	36
	13.	Ten stride test	$V_{m/s}$=6,65; L_m= 1,41; $F_{step/sec}$= 4,72
	14.	HGS Right hand (kg)	60.4
	15.	HGS Left hand (kg)	64
	16.	Throwing the ball 3kg standing - above the head (m)	11.14
	17.	Throwing the ball 3kg sitting - from the chest (m)	6.70
	18.	Throwing the ball 3kg - lying down above the head (m)	9.25
	19.	Ball throwing speed with 4 m - sitting (m/s)	15,27
	20.	Ball throwing speed with 7m - basic stance (m/s)	19.16
	21.	Ball throwing speed from 9m - jump shot (m/s)	18,05
	22.	Leg strength test (elastic) - jumps on one leg (sec)	5.12 - Above average
	23.	Sprint Bound Index (elastic) / SBI	SBI=72.38 (5.17 sec /14 kor)
	24.	Illinois agility run test (sec) vs. average speed (sec)	16.47sec - Average speed 3.95m/sec
	25.	T - drill test (sec)	11. 25
	26.	505 agility test (sec)	4. 73.
	27.	Zig - Zag test (sec)	6. 62
	28.	Test 96369- turn 180° (sec)	8. 80
	29.	Test 96369 -forward – back (sec)	9. 84
	30.	Run 15m (sec)	2.25
	31.	Run 30 (sec)	4.54
	32.	Run 100m (sec)	12.54
	33.	Run 200m (sec)	24.70
	34.	Run 400m (sec)	54.73
	35.	Run 800m (min)	2.13 - VO2max = 63.38ml/kg/min
	36.	Run 1500m (min)	4.27 – VO2 max = 62. 10 ml/kg/min
	37.	Race walking 2km (min)	12. 20
	38.	Running Sprint Anaerobic Test (RAST)	Max. power = 732 watts
			Average = 691 watts
			Fatigue Index = 2.67 Watts/sec

The results of our study (Table 1) define a wide range of motor and functional abilities of the subjects, and the number of measured parameters is an indicator of a studious approach in studying the fitness abilities of ski biathletes. A wide area of explosive strength, repetitive strength, coordination, endurance and flexibility is covered. The topological space of abilities by region was analyzed, as well as the abilities of the whole body (coordination tests). Fatigue index and maximum output power were also assessed through the RAST test. By looking at the individual measurement results of each parameter (variable), an extremely high level of development of all motor and functional abilities is evident. Some values are even in the range of values of sportsmen, e.g. athletes, sprinters, competitors in sports games (e.g. Ten stride test or SBI=72.38), etc. The achieved results are a confirmation of the exceptionality of our subject in terms of the development of fitness abilities, which is necessary today in the top sport. Despite the fact that some parameters (variables) may not be "direct" predictors of success in ski biathlon, it is important to point out the wide participation of these tests as a synergistic opus in the final result success.

If you were to analyze all the parameters individually, you would not be able to find any less important element. Impressive results were recorded for the parameters of repetitive

strength, explosive strength, static strength, sprinting speed, throwing speed, flexibility, agility, etc. (Table 1). All these parameters are characterized by a common motor output, from the aspect of movement regulation, that is, mechanisms of central and energy regulation. Some are responsible for the intensity of excitation, others for regulation of the duration of excitation, structuring of movement or synergistic regulation and regulation of muscle tone. In general, the results of our subject are characterized by a well-synchronized and highly integrated field of the functional model of motor abilities with a significant participation of physiological mechanisms. The values of muscle strength parameters (explosive and repetitive) of the upper and lower part of our competitor's body are indicators of adequate abilities that are necessary for the performance of sports technique, which supports earlier studies (Sandbakk et al., 2014; McGawley et al., 2014; Akay et al. et al., 2016; Köykkä et al., 2022).

In certain analyses, it is assumed that skiing technique explains different variations in competitive success from 59 to 65% (Dzhilkibaeva, Ahrens, & Laaksonen, 2019) and 42-54% (Luchsinger et al., 2019) of biathlon sprint and individual competitions, while accuracy and time shootings explain the rest of the variation. The results of running, which assessed the sprinting speed as well as the frequency of movement of our subject, are exceptional (Table 1), which is in accordance with previous studies (Stöggl, Enqvist, Muller, 2010; Stöggl et al., 2015; Danielsen et al., 2018;). No less good results were achieved in the explosive power of the lower extremities, which were used to assess horizontal jumpiness, and which are of great importance in biathlon running. All results in other defined motor abilities of our sample are indicators of an exceptional motor profile, which is an indicator of high integration, which is in accordance with previous studies (Schmit et al. 2020; Ryabov et al., 2023).

The result in biathlon is a consequence of a certain stress during skiing, shooting time and other specifics that are difficult to influence before the race, and above all the balance of the upright body, the surface and the posture on the skis (Skattebo, & Losnegard, 2018). Disturbed body balance is closely related to the stability of movements transmitted to the rifle, which have been shown to be closely related to shooting accuracy (Köykkä, et al. 2022). It is characterized by maximum intensity with certain breaks during rifle shooting, which makes this sport unique from the physiological point of view. In endurance sports, including cross-country skiing, VO2max sets the upper limit for oxygen consumption during exercise, which is strongly related to overall performance. In addition to high VO2max, well-developed economy or movement effects reduce overall energy expenditure during exercise (Joyner and Coyle, 2008) and may be equally important for overall performance, as observed in cross-country skiing (Sandbakk, Holmberg, Leirdal, et al., 2010; Andersson, Björklund, Holmberg, et al., 2017). A high value of VO2max was recorded in our subject. Some cross-country skiing studies show that VO2max and VO2 at lactate threshold are related to skiing performance in 10 km races. Furthermore, the average heart rate (HR) during biathlon running is high, at ~90% of HRmax and our sample result records a %HRmax of 86.28 beats (Mahood, Kenefick, Kertzer, et al., 2001; Losnegard, Myklebust, Spencer et al. 2013; Carlsson, Carlsson, Wedholm, et al., 2016)

When it comes to the functional segment, in addition to aerobic endurance, anaerobic energy delivery also plays an important role in high-intensity activities. It has been confirmed that work intensity >100% of VO2max is present on uphills during cross-country skiing (Andersson et al., 2017; Karlsson, Gilgien, Gløersen et al., 2018), while some laboratory simulations of a sprint race in cross-country skiing (about 3-4 minutes) suggest that is the relative contribution of anaerobic energy ~17-26% (Losnegard, Myklebust, & Hallen, 2012; McGawley and Holmberg, 2014; Tønnessen, Haugen, Hem, et al. 2015; McGawley, 2017). In our case, a good anaerobic capacity (A.V) was also recorded, measured through running disciplines and the RAST test, where Max. power 732watts, and Fatigue index 2.67watts/sec, which is an indicator of good anaerobic energy delivery for muscle work, which supports the

results of earlier studies (Noordhof, Koning, & Foster, 2010). Myakinchenko, Heil, Kriuchkov et al. 2022, Wang, 2023).

4. CONCLUSION

The presented results of the study provide a clear picture of the fitness profile of our ski biathlete. On the basis of the obtained results of a wide spectrum of the motor area, it can be concluded that precisely the motor abilities, along with an adequate morphological profile and body composition of the contestants, are extremely important in the resulting success. Also, the results of the study can serve as a kind of guide for future competitors in ski biathlon, with the aim of continuous training development of adequate motor skills of future competitors.

5. REFERENCES

Aminov, R.K.H., Razyapov, I.S. (2010). Model characteristics as a basis for increasing the effectiveness of the training process. XX Regional scientific - practical conference. Chelyabinsk, (pp. 13-16). EDN: TGBZFD

Akay, MF., About, F., Özçiloglu, M., & Heil, D. (2016). Identifying the discriminative predictors of upper body power of cross-country skiers using support vector machines combined with feature selection. Neural Comput. Appl. 27, 1785–1796.

Andersson, E., Björklund, G., Holmberg, H. C., & Ørtenblad, N. (2017). Energy system contributions and determinants of performance in sprint cross-country skiing. Scand J. Med. Sci. Sports 27, 385–398.

Bunc, V., Vávra, V & Levora, P. (2005). Body composition and selected maximal functional performance in top young biathletes. In: Müller, E., Bacharach, D., Klika, R., Lindinger, S., Schwameder, H. (Eds.). Science and Skiing III (pp. 300-307). Adelaide, Oxford, New York: Meyer and Meyer

Björklund, G, Laaksonen, MS. (2022). The Determinants of Performance in Biathlon World Cup Sprint and Individual Competitions. Front. Sports Act. Living. Sec. Sports Science, Technology and Engineering.4 https://doi.org/10.3389/fspor.2022.841619

Cholewa, J., Gerasimuk, D., Szepelawy, M. & Zajac, A. (2005). Analysis of the structure of the biathlon runs. Acta Universitatis Palackianae Olomucensis Gymnica, 35 (1), 35-42.

Carlson, R. (2011). Talent detection and competitive progress in biathlon – a national example. Polish Journal of Sport and Tourism, 18 (4), 290-295.

Carlsson, M., Carlsson, T., Wedholm, L., Nilsson, M., Malm, C., and Tonkonogi, M. (2016). Physiological demands of competitive sprint and distance performance in elite female cross-country skiing. J. Strength Cond. Res. 30, 2138–2144. doi: 10.1519/JSC.0000000000001327

Danielsen, J., Sandbakk, Ø., Mcghie, D., Ettema, G. (2018). The effect of exercise intensity on joint power and dynamics in ergometer double-poling performed by cross-country skiers. Hum. Mov. Sci., 57, 83–93.

Dzhilkibaeva, N., Ahrens, M., and Laaksonen, M. S. (2019). Can performance in biathlon world cup be predicted by performance analysis of biathlon IBU cup? Int. J. Perf. Anal. Spor. 19, 856–865.

Forbes, PA., Chen, A., & Blouin, JS. (2018). Sensorimotor control of standing balance. Handbook of clinical neurology, 159, 61–83.

Holmberg, H.C, Rosdahl, H., Svedenhag, J. (2007). Lung function, arterial saturation and oxygen uptake in elite cross country skiers: Influence of exercise mode. Scand. J. Med. Sci. Sports., 17 (4), 437–444.

Joyner, M. J., and Coyle, E. F. (2008). Endurance exercise performance: the physiology of champions. J. Physiol. 586, 35–44. doi: 10.1113/jphysiol.2007.143834

Köykkä, M., Laaksonen, MS, Ihalainen, S., Ruotsalainen, K., & Linnamo, V. (2022). Performance-determining factors in biathlon prone shooting without physical stress. Scandinavian journal of medicine & science in sports, 32 (2), 414–423. https://doi.org/10.1111/sms.14087

Kochergina, N., Chepulėnas, A. (2012). Indices Of Elite Female Biathletes' Age and Body Composition. Lase Journal of Sport Science. 3 (2), 69-78

Karlsson, Ø., Gilgien, M., Gløersen, Ø. N., Rud, B., and Losnegard, T. (2018). Exercise intensity during cross-country skiing described by oxygen demands in flat and uphill terrain. Front. Physiol. 9:846.

Koryagina, YU.V., Matuk, S.V. (2010). Morphological features of athletes as a result of adaptation to various strength sports. Omskiy nauchnyy vestnik. 4 (89), 140-142.

Losnegard, T., Myklebust, H., and Hallén, J. (2012). Anaerobic capacity as a determinant of performance in sprint skiing. Med. Sci. Sports Exerc. 44, 673–681. doi: 10.1249/MSS.0b013e3182388684

Losnegard, T., Myklebust, H., Spencer, M., and Hallen, J. (2013). Seasonal variations in VO2max, O2-cost, O2-deficit, and performance in elite cross-country skiers. J. Strength Cond. Res. 27, 1780–1790. doi: 10.1519/JSC.0b013e31827368f6

Laaksonen, M. S., Finkenzeller, T., Holmberg, H. C., and Sattlecker, G. (2018a). The influence of physiobiomechanical parameters, technical aspects of shooting, and psychophysiological factors on biathlon performance: a review. J. Sport Health Sci. 7, 394–404. doi: 10.1016/j.jshs.2018.09.003

Laaksonen, M. S., Jonsson, M., and Holmberg, H. C. (2018b). The olympic biathlon - recent advances and perspectives after Pyeongchang. Front. Physiol. 9:796. doi: 10.3389/fphys.2018.00796

Laaksonen, MS, Malin, AE, Kårström, MJ, Lindblom, H, McGawley. K.(2020). Laboratory-Based Factors Predicting Skiing Performance in Female and Male Biathletes. Frontiers in Sports and Active Living, doi:10.3389/fspor.2020.00099

Luchsinger, H., Kocbach, J., Ettema, G., and Sandbakk, Ø. (2018). Comparison of performance-levels and sex on sprint race performance in the biathlon world cup. Int. J. Sports Physiol. Perform. 13, 360–366. doi: 10.1123/ijspp.2017-0112

Luchsinger, H., Talsnes, Rk, Kocbach, J., & Sandbakk, Ø. (2019). Analysis of a Biathlon Sprint Competition and Associated Laboratory Determinants of Performance. Frontiers in sports and active living, 1, 60. https://doi.org/10.3389/fspor.2019.00060

Luchsinger, H., Kocbach, J., Ettema, G., and Sandbakk, Ø. (2019). The contribution from cross-country skiing and shooting variables on performance-level and sex differences in biathlon world cup individual races. Int. J. Sports Physiol. Perf. 14, 190–195. doi: 10.1123/ijspp.2018-0134

Luchsinger, H., Kocbach, J., Ettema, G., & Sandbakk, Ø. (2020). Contribution from cross-country skiing, start time and shooting components to the overall and isolated biathlon pursuit race performance. PloS one, 15 (9), e0239057. https://doi.org/10.1371/journal.pone.0239057

Lunghi, A., Brocherie, F., & Millet, GP (2019). Influence of Altitude on Elite Biathlon Performances. High Altitude Medicine & Biology, 20 (3), 312–317. https://doi.org/10.1089/ham.2019.0008

Lee, K.K., Yoon, L.S., & Seo, T. (2017). The relationship between performance factors and physical fitness in secondary school female biathlon athletes. Korean Journal of Sport Science, 28, 750-759.

McGawley, K., and Holmberg, H. C. (2014). Aerobic and anaerobic contributions to energy production among junior male and female cross-country skiers during diagonal skiing. Int. J. Sports Physiol. Perform. 9, 32–40. doi: 10.1123/ijspp.2013-0239

Mackenzie, B. (2005). 101 Performance Evaluation Tests. Published by: Electric Word plc. 67-71 Goswell Road London. https://www.brianmac.co.uk/eval.htm.

Mahood, N. V., Kenefick, R. W., Kertzer, R., and Quinn, T. J. (2001). Physiological determinants of cross-country ski racing performance. Med. Sci. Sports Exerc. 33, 1379–1384. doi: 10.1097/00005768-200108000-00020

McGawley, K. (2017). The reliability and validity of a four-minute running time-trial in assessing VO2max and performance. Front. Physiol. 8:270. doi: 10.3389/fphys.2017.00270

Manfredini, F., Manfredini, R., Carrabre, J. E., Litmanen, H., Zhukovskaja, L., Dal Fallo, D. et al., (2002). Competition load and stress in sports: a preliminary study in biathlon. International Journal of Sports Medicine, 23(5), 348-352

Myakinchenko, Heil, DP, Kriuchkov AS, Feofilaktov, VV, Kuzmichev VA, Adodin, NV. (2022). Physiological profiles and training loads of international level male and female cross-country skiers and biathletes. Science & Sports. 37 (5–6), 490.e1-490.e10

Noordhof, D. A., Koning, J. J., and Foster, C. (2010). The maximal accumulated oxygen deficit method: a valid and reliable measure of anaerobic capacity. Sports Med. 40, 285–302.

Preobrazhentsev, Yu. F. (2007). Comparative analysis of contest activities of high mastery biathletes in the season of 2006-2007. Collection of scientific works dedicated to the 70th anniversary of the formation of the Department of Theory and Methods of Skiing of the Russian State University of Physical Culture (pp. 32-38). Moscow: RGUFK

Psotta, R., Sviráková, D., Bunc, V., Šeflová, I., Hrásky, P. & Martin, J. (2009). Aerobic fitness, running performance and body composition of Czech elite male summer biathletes. Fitness Society of India, 5 (1), 41-49.

Ryabov, A.A., Ryabova, E.K., Zebzeev, V.V., Chumakov, V.N. (2023). Model characteristics of morphological indicators of the body composition of ski jumpers and nordic combined skiers. Theory and Practice of Physical Culture, 2, 40-43

Sandbakk, Ø., and Holmberg, H. C. (2014). A reappraisal of success factors for Olympic cross-country skiing. Int. J. Sports Physiol. Perform. 9, 117–121.

Skattebo, Ø., & Losnegard, T. (2018). Variability, Predictability, and Race Factors Affecting Performance in Elite Biathlon. International Journal of Sports Physiology and Performance, 13 (3), 313–319. https://doi.org/10.1123/ijspp.2017-0090

Schmitt, L, Bouthiaux S, Eleven, G. (2020). Years' Monitoring of the World's Most Successful Male Biathlete of the Last Decade. International Journal of Sports Physiology and Performance.16 (6), 900/905.

Stöggl,, T., Enqvist, J., Muller, E., Holmberg H.C. (2010). Relationships between body composition, body dimensions, and peak speed in cross-country sprint skiing. J Sports Sci. 28 (2), 161-9.

Stöggl, R., Muller, E., & Stöggl, T. (2015). Motor abilities and anthropometrics in youth cross-country skiing. Scand. J. Med. Sci. Sports 25, e70–81.

Vickers, J. N., Williams, A. M. (2007). Performing under pressure the effects of physiological arousal, cognitive anxiety and gaze control in biathlon. Journal of Motor Behavior, 39 (5), 381-394

Wang, D (2023). The Differences Between Modern Modes Of Biathlon Training At The Olympic Winter Games. Rev Bras Med Esporte. 29, e2022_0300, pp. 1-4

Zebzeev, V.V., Zdanovich, O.S. (2016). Morphology as an innovative approach in assessing the technique of ski jumping. Scientific notes of the University named after. P.F. Lesgafta. 1 (131), 91-95.