Original article
DOI: 10.14529/hsm260102

DIFFERENCES IN BODY COMPOSITION BETWEEN MALE AND FEMALE SKI JUMPING, NORDIC COMBINED, AND BIATHLON ATHLETES

***V.V. Zebzeyev*[1]**, *pro_nir@chgafkis.ru, https://orcid.org/0000-0002-4409-8754*
***M. Vulic*[2]**, *marinara85@gmail.com, https://orcid.org/0000-0003-4781-3706*
***O.S. Zdanovich*[1]**, *solic8233@yandex.ru, https://orcid.org/0000-0001-6671-8961*
***V.A. Vetrov*[1]**, *vetrov.vladimir@list.ru, https://orcid.org/0009-0002-3272-6212*
***E.K. Ryabova*[1]**, *laboratory.chgafkis@gmail.com, https://orcid.org/0000-0002-2798-456X*
[1] *Tchaikovsky State Physical Education and Sports Academy, Tchaikovsky, Russia*
[2] *Health Centre Vracar, Belgrade, Serbia*

Abstract. **Aim.** The study aimed to identify differences in general and regional body composition indicators between male and female athletes in ski jumping, Nordic combined, and biathlon. **Materials and Methods.** The study involved 320 athletes divided into three groups: Group 1 – ski jumpers (n = 85), Group 2 – Nordic combined skiers (n = 144), and Group 3 – biathletes (n = 91). General and regional body composition indicators were measured using bioelectrical impedance analysis (BIA). **Results.** Significant differences were observed among male ski jumpers, Nordic combined skiers, and biathletes ($p < 0.01$) in body mass, BMI, muscle mass, protein mass, fluid volume, and regional muscle mass of the arms and trunk. Ski jumpers differed significantly from biathletes in fat mass and regional fat mass of the trunk and legs. Nordic combined skiers differed significantly from biathletes in fat mass and regional fat mass of the trunk and legs. Female athletes from the three groups differed in body mass, muscle mass, protein mass, and regional muscle mass of the arms and trunk. Female ski jumpers and Nordic combined skiers differed in fat mass. Female biathletes differed from female ski jumpers in height, fluid volume, regional fat mass of the arms, and regional muscle and fat mass of the left leg. Female biathletes differed from female Nordic combined skiers in fat mass, fluid volume, regional fat mass of the arms and calves, and regional muscle mass of the legs. **Conclusion.** The specific demands of ski jumping, Nordic combined, and biathlon lead to distinct adaptations in athletes' body composition. The established differences in general and regional body composition indicators are of great importance for specialists in these sports and can be used as markers in the athletic selection system.

Keywords: body composition, ski jumping, Nordic combined, biathlon

For citation: Zebzeyev V.V., Vulic M., Zdanovich O.S., Vetrov V.A., Ryabova E.K. Differences in body composition between male and female ski jumping, Nordic combined, and biathlon athletes. *Human. Sport. Medicine*. 2026;26(1):16–23. DOI: 10.14529/hsm260102

Научная статья
УДК 796.92
DOI: 10.14529/hsm260102

РАЗЛИЧИЯ В СОСТАВЕ ТЕЛА СПОРТСМЕНОВ В ПРЫЖКАХ НА ЛЫЖАХ С ТРАМПЛИНА, ЛЫЖНОМ ДВОЕБОРЬЕ И БИАТЛОНЕ В ЗАВИСИМОСТИ ОТ ПОЛА

В.В. Зебзеев[1], *pro_nir@chgafkis.ru, https://orcid.org/0000-0002-4409-8754*
М. Вулич[2], *marinara85@gmail.com, https://orcid.org/0000-0003-4781-3706*
О.С. Зданович[1], *solic8233@yandex.ru, https://orcid.org/0000-0001-6671-8961*
В.А. Ветров[1], *vetrov.vladimir@list.ru, https://orcid.org/0009-0002-3272-6212*
Э.К. Рябова[1], *laboratory.chgafkis@gmail.com, https://orcid.org/0000-0002-2798-456X*
[1] *Чайковская государственная академия физической культуры и спорта, Чайковский, Россия*
[2] *Центр здоровья Вракар, Белград, Сербия*

Аннотация. **Цель:** выявление различий в общих и региональных показателях состава тела у спортсменов в прыжках на лыжах с трамплина, лыжном двоеборье и биатлоне в зависимости от пола. **Материалы и методы.** В исследовании приняли участие 320 спортсменов, разделенных на три группы: прыгуны с трамплина (n = 85), лыжники-двоеборцы (n = 144) и биатлонисты (n = 91). У данных спортсменов проведены измерения состава тела посредством биоимпедансометрии. **Результаты.** У мужчин наблюдалась разница между прыгунами с трамплина, двоеборцами и биатлонистами ($p < 0{,}01$) в показателях ИМТ, массы тела, мышц, белка, количества жидкости, региональной мышечной массы рук и туловища. Прыгуны с трамплина значительно отличаются от биатлонистов по жировой массе тела, региональной жировой массе туловища и ног. Двоеборцы значительно отличаются от биатлонистов по жировой массе, региональной жировой массе туловища и ног. Спортсменки трех групп различаются по массе тела, мышц, белка, мышечной массе рук и туловища. Спортсменки в прыжках с трамплина и двоеборье имеют различия в массе жира. Биатлонистки отличаются от прыгуний с трамплина по росту, количеству жидкости, региональной жировой массе рук, региональной мышечной и жировой массе левой ноги. Биатлонистки отличаются от лыжниц-двоеборок по жировой массе, количеству жидкости, региональной жировой массе рук и голеней, региональной мышечной массе ног. **Заключение.** Специфика нагрузок в прыжках с трамплина, лыжном двоеборье и биатлоне приводит к изменениям в составе тела спортсменов. Установленные различия в общих и региональных показателях состава тела имеют большое значение для специалистов по этим видам спорта и могут быть использованы как маркеры в системе спортивного отбора.

Ключевые слова: состав тела, прыжки на лыжах с трамплина, лыжное двоеборье, биатлон

Для цитирования: Differences in body composition between male and female ski jumping, Nordic combined, and biathlon athletes / V.V. Zebzeyev, M. Vulic, O.S. Zdanovich et al. // Человек. Спорт. Медицина. 2026. Т. 26, № 1. С. 16–23. DOI: 10.14529/hsm260102

Introduction. Ski jumping (SJ), Nordic combined (NC), and biathlon (Bia) are Olympic skiing disciplines that share the fundamental element of sliding on snow, yet differ markedly in the conditions and duration of this activity. Ski jumpers perform two jumps from hills of 90–95 m or larger. To maximize performance, athletes must assume exactly an optimal stable body position throughout all jump phases: the in-run, take-off, early flight, stable flight, landing preparation, and landing [6]. Body composition is one of the significant factors influencing the explosive power of ski jumpers [4]. Athletes with a lower weight and BMI achieve longer jumps due to less influence of gravity on them during flight [15]. Accordingly, maintaining a low body weight in combination with an optimal ratio of muscle and adipose tissue can contribute to the development of maximum speed and strength of movement in this sport [13]. Nordic Combined skiers first complete a ski jump, followed immediately by a cross-country ski pursuit race. The ski jump in Nordic Combined demands short-duration movements powered primarily by the alactic-anaerobic energy system, requiring high levels of explosive power and coordination [1]. During a cross-country ski race, Nordic Combined skiers perform movement techniques mainly in aerobic mode [14]. To achieve high athletic results, an optimal body size and physique are required, characteristic of NC [14]. Evidence suggests that heavier skiers possess an advantage on flat and downhill sections, while lighter skiers dominate on steep uphill terrain [9]. Biathlon combines cross-country skiing with intermittent shooting from prone and standing positions. Missed shots increase the competitive distance and time. An important factor affecting the athlete's movement technique in the race is the presence of a rifle, which the biathlete carries during the competition [5]. Like NC, biathlon places high demands on aerobic capacity. However, during a ski race in biathlon, athletes have the opportunity to recover a little during shooting breaks, which is impossible in NC or cross-country skiing. Therefore, the ski race in biathlon is characterized by an aerobic-anaerobic energy mode of operation [10]. However, carrying the rifle imposes additional requirements for strength throughout the distance [5]. Achieving high athletic results in biathlon requires athletes to develop a high level of strength endurance with a minimum amount of adipose tissue [17].

Various methods are used to assess body composition, but bioelectric impedance analysis (BIA) is a simple and reliable tool [11]. Body composition indicators can therefore be used to assess athletic potential and optimize selection during certain stages of athletic development [12]. In early development stages, athletes can participate in multiple related sports. For example, youth may compete in both SJ and NC or in both cross-country skiing and Bia. However, the effect of differences in total and regional body composition indicators on the type of sport remains unclear. A detailed assessment of total and regional body composition could therefore provide a useful tool for coaches to identify and select athletes with the greatest potential for success in SJ, NC, or Bia. Therefore, the aim of this study was to identify differences in total and regional body composition indicators depending on the specifics of ski jumping, Nordic combined, and biathlon.

Materials and Methods. ***Participants.*** The research involved 320 athletes over the age of 18 to 26. The study sample consisted of ski jumpers (26 men, 59 women), Nordic combined skiers (108 men, 36 women), and biathletes (37 men, 54 women). All participants were members of either Russian regional national teams or the Russian national team itself and had competed in all-Russian and international competitions between 2014 and 2022. Prior to participation, all athletes provided written informed consent.

Measurements and Conditions. Data collection was carried out in the period from 2014 to 2022 during training camps for athletes. Standing height was measured to the nearest 0.1 cm using a stadiometer, with participants barefoot. Body composition was assessed using an 8-electrode InBody 720 impedance meter (Biospace Corp., Seoul, Korea). All measurements were performed by the same qualified specialist at a temperature of 21–22 °C between 07:00 and 08:30. All participants were in a fasted state, with the preceding evening meal concluding before 20:00. Prior to testing, participants abstained from exercise, showering, and medication use. All body composition measurements were performed in a standing position. For female participants, measurements were scheduled to avoid the menstrual period (i.e., not within 7 days before or during menstruation). Participants were instructed to remove all metal objects and electronic devices prior to measurement. BIA has high reliability and accuracy and is considered an objective method in assessing body composition. The In Body 720 body composition analyzer provides direct segmental impedance measurements from various body compartments (trunk, arms, and legs), enabling the evaluation of both total and regional body composition indices.

Statistical Analysis. All statistical analyses were performed using IBM SPSS Statistics 20. Basic descriptive statistics were calculated and all data were checked for normality of distribution. The Student t test for independent variables was used to evaluate the mean differences. Results are presented as mean ± standard deviation. Statistical significance was set at $p < 0.05$.

Results. The basic demographic, anthropometric, and total and regional body composition characteristics of the participants, stratified by sex, are presented in Table 1.

As shown in Table 2, significant differences ($p < 0.01$) were observed among male ski jumpers, Nordic combined skiers, and biathletes for nine body composition variables. These included body weight, BMI, and the masses of muscle, minerals, protein, and fluids, as well as the regional muscle mass of the trunk and both arms. Furthermore, male biathletes exhibited significantly lower total fat mass and regional fat mass of the trunk and legs compared to Nordic com-

Table 1

Demographic, anthropometric and body composition characteristics of the examined groups, Mean ± SD

Показатель Parameter	Ski jumping		Nordic combined		Biathlon	
	Men (n = 26)	Women (n = 59)	Men (n = 108)	Women (n = 36)	Men (n = 37)	Women (n = 54)
Age (years)	21.04 ± 2.11	21.2 ± 2.83	20.26 ± 2.11	20.3 ± 2.63	20.38 ± 2.10	21.46 ± 3.2
Height (cm)	176.46 ± 9.58	165.28 ± 5.6	177.62 ± 5.91	165.68 ± 5.36	177.49 ± 5.41	167.71 ± 4.9
Weight (kg)	61.29 ± 7.67	53.71 ± 5.79	67.39 ± 5.09	57 ± 4.89	72.04 ± 6.75	59.36 ± 5.96
BMI (kg/m^2)	19.56 ± 1.08	19.5 ± 1.47	21.25 ± 0.98	21.14 ± 2.72	22.82 ± 1.81	21.08 ± 1.55
MM (kg)	33.45 ± 7.89	24.77 ± 2.81	35.66 ± 3.41	26.07 ± 2.51	37.48 ± 3.14	28.16 ± 2.96
FM (kg)	4.60 ± 1.31	9.16 ± 3.67	5.16 ± 2.22	11.64 ± 9.4	6.61 ± 3.01	9.19 ± 3.67
MinM (kg)	3.76 ± 0.53	3.09 ± 0.33	4.19 ± 0.36	3.25 ± 0.3	4.43 ± 0.39	3.47 ± 0.33
PM (kg)	11.36 ± 1.57	8.87 ± 0.93	12.49 ± 1.14	9.31 ± 0.83	13.09 ± 1.05	10 ± 0.98
Fluid (L)	36.55 ± 12.04	30.4 ± 7.24	44.50 ± 6.87	31.13 ± 7.78	47.83 ± 3.85	36.7 ± 3.53
RMMRA (kg)	3.14 ± 0.69	2.14 ± 0.35	3.52 ± 0.48	2.3 ± 0.36	3.76 ± 0.43	2.6 ± 0.36
RFMRA (kg)	0.17 ± 0.09	0.54 ± 0.25	0.21 ± 0.19	0.56 ± 0.11	0.23 ± 0.17	0.47 ± 0.26
RMMLA (kg)	3.10 ± 0.64	2.11 ± 0.3	3.49 ± 0.47	2.28 ± 0.35	3.78 ± 0.42	2.61 ± 0.38
RFMLA (kg)	0.25 ± 0.37	0.56 ± 0.25	0.21 ± 0.18	0.56 ± 0.12	0.22 ± 0.14	0.47 ± 0.27
RMMT (kg)	25.15 ± 4.16	19.25 ± 1.97	27.35 ± 2.81	20.11 ± 2.17	28.78 ± 2.43	22 ± 2.22
RFMT (kg)	1.44 ± 0.81	4.04 ± 2.11	2.03 ± 1.64	4.37 ± 1.25	3.22 ± 1.72	4.08 ± 1.78
RMMRL (kg)	9.43 ± 1.62	7.05 ± 0.86	9.85 ± 1.14	7.15 ± 0.84	9.95 ± 0.77	7.61 ± 0.88
RFMRL (kg)	0.92 ± 0.24	1.62 ± 0.55	1.02 ± 0.42	1.67 ± 0.23	1.17 ± 0.32	1.54 ± 0.54
RMMLL (kg)	9.38 ± 1.61	7.05 ± 0.86	9.76 ± 1.29	7.17 ± 0.9	9.90 ± 0.78	7.59 ± 0.87
RFMLL (kg)	0.93 ± 0.25	1.62 ± 0.55	1.04 ± 0.65	1.67 ± 0.24	1.16 ± 0.35	1.52 ± 0.53

Note: MM – muscle mass, FM – fat mass, MinM – mineral mass, PM – protein mass, RMMRA – regional muscle mass of the right arm, RFMRA – regional fat mass of the right arm, RMMLA – regional muscle mass of the left arm, RFMLA – regional fat mass of the left arm, RMMT – regional muscle mass of the trunk, RFMT – regional fat mass of the trunk, RMMRL – regional muscle mass of the right leg, RFMRL – regional fat mass of the right leg, RMMLL – regional muscle mass of the left leg, RFMLL – regional fat mass of the left leg.

bined skiers and ski jumpers ($p < 0.01$). For other variables, no significant differences between the mean values ($p > 0.05$) were found.

Table 3 presents the differences among female athletes in ski jumping, Nordic combined, and biathlon. The analysis revealed that female athletes across all three groups differed significantly ($p < 0.01$, $p < 0.05$) in seven indicators: weight, BMI, fat mass, mineral mass, and regional muscle mass of the arms and trunk. Female biathletes differed significantly from the female ski jumpers and Nordic combined skiers ($p < 0.01$, $p < 0.05$) in terms of height, protein mass, regional muscle mass of the right and left arms and legs, and regional fat mass of the right and left legs. Female ski jumpers differed significantly from the female biathletes and Nordic combined skiers in the indicator of body fluid ($p < 0.01$). Moreover, female biathletes differed significantly from female Nordic combined skiers in muscle mass ($p < 0.01$). No significant differences were found for the remaining variables ($p > 0.05$).

Discussion. We aimed to investigate body composition differences based on the type of skiing sport. Our data showed that male ski jumpers, Nordic combined skiers, and biathletes differ significantly ($p < 0.01$) in overall body measures: weight, BMI, and the mass of muscle, minerals, protein, and fluid. However, regarding regional differences, the disparities were more notable in muscle mass than in fat mass. Specifically, the upper limb and central distribution of muscle mass differed among all three groups, while no inter-group differences in upper limb fat mass were present. Differences in central and lower limb fat mass were found between Groups 1–3 and 2–3. Consistent with the central fat mass results, male ski jumpers and Nordic combined skiers had lower levels of lower limb fat mass compared to biathletes. These results may point to different patterns of energy expenditure in the upper limbs with respect to muscle mass development, as well as to the significance of sport-specific selection for fat mass distribution.

Table 2

Inter-sport differences between athletes in Ski jumping, Nordic combined and Biathlon (men), Mean ± SD

	Ski jumpers (n = 26)	Nordic combined skiers (n = 108)	Biathletes (n = 37)	$p_{1–2}$	$p_{1–3}$	$p_{2–3}$
Age (years)	21.04 ± 2.11	20.26 ± 2.11	20.38 ± 2.10	0.082	0.224	0.694
Height (cm)	176.46 ± 9.58	177.62 ± 5.91	177.49 ± 5.41	0.953	0.95	0.99
Weight (kg)	61.29 ± 7.67	67.39 ± 5.09	72.04 ± 6.75	**0.001**	**0.001**	**0.001**
BMI (kg/m^2)	19.56 ± 1.08	21.25 ± 0.98	22.82 ± 1.81	**0.001**	**0.001**	**0.001**
MM (kg)	33.45 ± 7.89	35.66 ± 3.41	37.48 ± 3.14	**0.002**	**0.001**	**0.004**
FM (kg)	4.60 ± 1.31	5.16 ± 2.22	6.61 ± 3.01	0.185	**0.001**	**0.004**
MinM (kg)	3.76 ± 0.53	4.19 ± 0.36	4.43 ± 0.39	**0.001**	**0.001**	**0.001**
PM (kg)	11.36 ± 1.57	12.49 ± 1.14	13.09 ± 1.05	**0.001**	**0.001**	**0.003**
Fluid (L)	36.55 ± 12.04	44.50 ± 6.87	47.83 ± 3.85	**0.001**	**0.001**	**0.002**
RMMRA (kg)	3.14 ± 0.69	3.52 ± 0.48	3.76 ± 0.43	**0.001**	**0.001**	**0.006**
RFMRA (kg)	0.17 ± 0.09	0.21 ± 0.19	0.23 ± 0.17	0.516	0.166	0.38
RMMLA (kg)	3.10 ± 0.64	3.49 ± 0.47	3.78 ± 0.42	**0.001**	**0.001**	**0.001**
RFMLA (kg)	0.25 ± 0.37	0.21 ± 0.18	0.22 ± 0.14	0.79	0.868	0.597
RMMT (kg)	25.15 ± 4.16	27.35 ± 2.81	28.78 ± 2.43	**0.002**	**0.001**	**0.005**
RFMT (kg)	1.44 ± 0.81	2.03 ± 1.64	3.22 ± 1.72	0.056	**0.001**	**0.001**
RMMRL (kg)	9.43 ± 1.62	9.85 ± 1.14	9.95 ± 0.77	0.261	0.088	0.422
RFMRL (kg)	0.92 ± 0.24	1.02 ± 0.42	1.17 ± 0.32	0.418	**0.001**	**0.008**
RMMLL (kg)	9.38 ± 1.61	9.76 ± 1.29	9.90 ± 0.78	0.29	0.093	0.417
RFMLL (kg)	0.93 ± 0.25	1.04 ± 0.65	1.16 ± 0.35	0.55	**0.003**	**0.003**

Note: Here and in Table 3 $p_{1–2}$ – ski jumpers vs. Nordic combined skiers, $p_{1–3}$ – ski jumpers vs. biathletes, $p_{2–3}$ – Nordic combined skiers vs. biathletes; MM – muscle mass, FM – fat mass, MinM – mineral mass, PM – protein mass, RMMRA – regional muscle mass of the right arm, RFMRA – regional fat mass of the right arm, RMMLA – regional muscle mass of the left arm, RFMLA – regional fat mass of the left arm, RMMT – regional muscle mass of the trunk, RFMT – regional fat mass of the trunk, RMMRL – regional muscle mass of the right leg, RFMRL – regional fat mass of the right leg, RMMLL – regional muscle mass of the left leg, RFMLL – regional fat mass of the left leg.

Table 3

Inter-sport differences between athletes in Ski jumping, Nordic combined and Biathlon (women), Mean ± SD

	Ski jumpers (n = 59)	Nordic combined skiers (n = 36)	Biathletes (n = 54)	$p_{1–2}$	$p_{1–3}$	$p_{2–3}$
Age (years)	21.2 ± 2.83	20.3 ± 2.63	21.46 ± 3.2	0.208	0.688	0.159
Height (cm)	165.28 ± 5.6	165.68 ± 5.36	167.71 ± 4.9	0.531	**0.002**	**0.039**
Weight (kg)	53.71 ± 5.79	57 ± 4.89	59.36 ± 5.96	**0.003**	**0.001**	**0.021**
BMI (kg/m^2)	19.5 ± 1.47	21.14 ± 2.72	21.08 ± 1.55	**0.004**	**0.001**	**0.001**
MM (kg)	24.77 ± 2.81	26.07 ± 2.51	28.16 ± 2.96	0.080	0.567	**0.011**
FM (kg)	9.16 ± 3.67	11.64 ± 9.4	9.19 ± 3.67	**0.004**	**0.001**	**0.001**
MinM (kg)	3.09 ± 0.33	3.25 ± 0.3	3.47 ± 0.33	**0.004**	**0.001**	**0.001**
PM (kg)	8.87 ± 0.93	9.31 ± 0.83	10 ± 0.98	0.087	**0.001**	**0.001**
Fluid (L)	30.4 ± 7.24	31.13 ± 7.78	36.7 ± 3.53	**0.001**	**0.001**	0.548
RMMRA (kg)	2.14 ± 0.35	2.3 ± 0.36	2.6 ± 0.36	**0.009**	**0.001**	**0.001**
RFMRA (kg)	0.54 ± 0.25	0.56 ± 0.11	0.47 ± 0.26	0.682	**0.004**	**0.001**
RMMLA (kg)	2.11 ± 0.3	2.28 ± 0.35	2.61 ± 0.38	**0.002**	**0.001**	**0.001**
RFMLA (kg)	0.56 ± 0.25	0.56 ± 0.12	0.47 ± 0.27	0.865	**0.001**	**0.001**
RMMT (kg)	19.25 ± 1.97	20.11 ± 2.17	22 ± 2.22	**0.012**	**0.001**	**0.001**
RFMT (kg)	4.04 ± 2.11	4.37 ± 1.25	4.08 ± 1.78	0.372	0.792	0.185
RMMRL (kg)	7.05 ± 0.86	7.15 ± 0.84	7.61 ± 0.88	0.342	**0.001**	**0.010**
RFMRL (kg)	1.62 ± 0.55	1.67 ± 0.23	1.54 ± 0.54	0.736	**0.024**	**0.002**
RMMLL (kg)	7.05 ± 0.86	7.17 ± 0.9	7.59 ± 0.87	0.416	**0.001**	**0.014**
RFMLL (kg)	1.62 ± 0.55	1.67 ± 0.24	1.52 ± 0.53	0.736	**0.007**	**0.001**

Interestingly, for athletes in these sports, upper limb muscle mass, central fat mass, and lower limb fat mass showed a greater capacity to vary by sport type than lower limb muscle mass. Correspondingly, in male athletes, upper limb and central muscle mass, along with central and lower limb fat mass, demonstrated greater sport-specific variability than upper limb fat mass and lower limb muscle mass.

Specifically, in men, athletic training for a particular sport affects muscle mass, which can be used as a reliable predictor for athletic selection in these sports. In terms of body composition based on gender, men have more muscle mass than women [8]. In addition, a greater number of strength training exercises are used in the training process for men, developing the strength of the upper and lower limbs and the central part, depending on muscle and fat mass [12].

The analysis revealed that women have a greater number of regional body composition parameters that vary depending on the type of sport compared to men. Only trunk fat mass showed no significant differences among all female groups. In female athletes, overall body measures differed between groups. Regarding differences in upper limb muscle mass, these were present between all groups, but upper limb fat mass differences were present only between groups 1–3 and groups 2–3. Also, lower limb muscle and fat mass differed between Groups 1–3 and Groups 2–3. Interestingly, the group of female biathletes had the highest central muscle mass, followed by Nordic combined skiers, while female ski jumpers had the lowest.

Men and women in the ski jumping and Nordic combined groups showed no significant differences in a number of regional body composition indicators. This fact can be explained by the closely related specifics of sports training for these disciplines. A significant objective of this training is to maintain a low body weight alongside a properly balanced ratio of muscle to adipose tissue, which increases the likelihood of a longer jump [13, 14].

The influence of sex cannot be underestimated in relation to body shape [2], particularly in sports [16]; therefore, we divided the groups by gender. Increased lean body mass may enhance anaerobic power and capacity [16], as has been investigated in swimming. Our data indicate a high level of difference in muscle and fat distribution in the limbs but a lower level of difference in central fat mass based on the type of skiing sport, especially in females. The highest amount of lean mass was noted in the upper limb and central region of biathletes compared to the other groups. At the same time, female biathletes differed significantly from ski jumpers and Nordic combined skiers in regional indicators of upper and lower limb fat. This pattern can be explained by the specificity of the training process in the sports under study [4]. However, research in this field remains insufficient.

During high energy-expenditure exercise, the most dominant fat loss occurs in the central region, more than in subcutaneous fat [7]. The three types of skiing studied resulted in similar central fat mass in females. On the other hand, muscle development in skiing is very prominent in the upper limb and central region and differs between types of skiing in both male and female skiers. It has already been reported that a large amount of lean body mass, especially in the arms, could be of great importance for cross-country skiing performance [16].

Women have a higher level of body fat [2]. This may be the reason for the absence of an intersport difference in central fat mass among women. It has been observed that gender-related strength differences are more pronounced in the upper body [2].

Body composition is one of the leading components of sport performance. Every fitness component can be linked to regional body composition to some extent. While higher lean body mass enables the generation of greater strength, excess body fat can limit endurance, balance, coordination, and movement capacity [3]. We have demonstrated statistically significant intersport differences in regional lean and fat mass. It would be of interest to evaluate body composition in relation to the best performance and competitive results in each specific sport.

The results of previous studies [6, 13, 14] show that a common morphological factor exists among the predictor variables that evaluate motor potential, performance, and competitive achievements of athletes, accounting for the body constitution and the specificity of athletic training in different sports.

Conclusion. Male ski jumpers, Nordic combined athletes, and biathletes differ in upper limb muscle mass, central fat mass, and lower limb fat mass. Female ski jumpers, Nordic combined athletes, and biathletes differ in almost every regional body composition parameter except central fat mass. The smallest body composition differences were observed between female ski jumpers and Nordic combined skiers. These results can be used to track physical performance and identify body markers predisposing athletes to peak performance.

References

1. Bassett D.R. Jr., Howley E.T. Limiting Factors for Maximum Oxygen Uptake and Determinants of Endurance Performance. *Medicine & Science in Sports & Exercise*, 2000, vol. 32, no. 1, pp. 70–84. DOI: 10.1097/00005768-200001000-00012

2. Ben Mansour G., Kacem A., Ishak M. et al. The Effect of Body Composition on Strength and Power in Male and Female Students. *BMC Sports Science, Medicine and Rehabilitation*, 2021, vol. 13, no. 1, p. 150. DOI: 10.1186/s13102-021-00376-z

3. Campa F., Toselli S., Mazzilli M. et al. Assessment of Body Composition in Athletes: A Narrative Review of Available Methods with Special Reference to Quantitative and Qualitative Bioimpedance Analysis. *Nutrients*, 2021, vol. 13, no. 5, p. 1620. DOI: 10.3390/nu13051620

4. Janura M., Cabell L., Svoboda Z., Elfmark M. Evaluation of Explosive Power Performance in Ski Jumpers and Nordic Combined Competitive Athletes: A 19-Year Study. *The Journal of Strength and Conditioning Research*, 2016, vol. 30, no. 1, pp. 71–80. DOI: 10.1519/JSC.0000000000001046

5. Jonsson Kårström M., Stöggl T., Ohlsson M.L. et al. Kinematical Effects of Rifle Carriage on Roller Skiing in Well-trained Female and Male Biathletes. *Scandinavian Journal of Medicine and Science in Sports*, 2023, vol. 33, no. 4, pp. 444–454. DOI: 10.1111/sms.14276

6. Jošt B. The Hierarchical Structure of Selected Morphological and Motoric Variables in Ski Jumping. *Human Movement*, 2010, vol. 11, no. 2, pp. 124–131. DOI: 10.2478/v10038-010-0016-0

7. Kolnes K.J., Petersen M.H., Lien-Iversen T. et al. Effect of Exercise Training on Fat Loss-Energetic Perspectives and the Role of Improved Adipose Tissue Function and Body Fat Distribution. *Frontiers in Physiology*, 2021, vol. 12, 737709. DOI: 10.3389/fphys.2021.737709

8. Lichti J., Maggioni M.A., Balcerek B. et al. The Relevance of Body Composition Assessment for the Rating of Perceived Exertion in Trained and Untrained Women and Men. *Frontiers in Physiology*, 2023, vol. 14, 1188802. DOI: 10.3389/fphys.2023.1188802

9. Losnegard T., Hallén J. Physiological Differences between Sprint- and Distance-specialized Cross-country Skiers. *International Journal of Sports Physiology and Performance*, 2014, vol. 9, no. 1, pp. 25–31. DOI: 10.1123/ijspp.2013-0066

10. Luchsinger H., Kocbach J., Ettema G., Sandbakk Ø. Contribution from Cross-country Skiing, Start Time and Shooting Components to the Overall and Isolated Biathlon Pursuit Race Performance. *PLoS One*, 2020, vol. 15, no. 9, e0239057. DOI: 10.1371/journal.pone.0239057

11. Melchiorri G., Viero V., Sorge R. et al. Body Composition Analysis to Study Long-term Training Effects in Elite Male Water Polo Athletes. *Journal of Sports Medicine and Physical Fitness*, 2018, vol. 58, no. 9, pp. 1269–1274. DOI: 10.23736/S0022-4707.17.07208-5

12. Min S.K., Lim S.T., Lee K.K. Differences in Body Composition and Physical Fitness of Korean National Bobsleigh and Skeleton Athletes. *Journal Sports Medicine Physical Fitness*, 2022, vol. 62, no. 8, pp. 1071–1077. DOI: 10.23736/S0022-4707.21.12700-8

13. Ostachowska-Gąsior A., Piwowar M., Zając J. Segmental Phase Angle and Body Composition Fluctuation of Elite Ski Jumpers between Summer and Winter FIS Competitions. *International Journal of Environmental Research and Public Health*, 2021, vol. 18, no. 9, p. 4741. DOI: 10.3390/ijerph18094741

14. Sandbakk Ø., Rasdal V., Bråten S. et al. How Do World-Class Nordic Combined Athletes Differ From Specialized Cross-Country Skiers and Ski Jumpers in Sport-Specific Capacity and Training Characteristics? *International Journal of Sports Physiology and Performance*, 2016, vol. 11, no. 7, pp. 899–906. DOI: 10.1123/ijspp.2015-0285

15. Virmavirta M., Kivekäs J. Is it Still Important to be Light in Ski Jumping? *Sports Biomechanics*, 2021, vol. 20, no. 4, pp. 407–418. DOI: 10.1080/14763141.2018.1556326

16. Zera J.N., Nagle E.F., Connell E. et al. Gender Differences and the Influence of Body Composition on Land and Pool-Based Assessments of Anaerobic Power and Capacity. *International Journal of Environmental Research and Public Health,* 2022, vol. 19, no. 13, p. 7902. DOI: 10.3390/ijerph19137902

17. Zimmermann P., Moser O., Eckstein M.L. et al. Athlete's Heart in Elite Biathlon, Nordic Cross-Country and Ski-Mountaineering Athletes: Cardiac Adaptions Determined Using Echocardiographic Data. *Journal of Cardiovascular Development and Disease*, 2021, vol. 9, no. 1, p. 8. DOI: 10.3390/jcdd9010008

Information about the authors

Vladimir V. Zebzeyev, Doctor of Pedagogical Sciences, Professor, Vice-Rector for Research, Tchaikovsky State Physical Education and Sport Academy, Tchaikovsky, Russia.

Marina Vulic, MD, PhD, Specialist of Internal Medicine, Health Centre Vracar, Department of Internal Medicine, Belgrade, Serbia.

Olga S. Zdanovich, Candidate of Pedagogical Sciences, Associate Professor, Department of Theory and Methodology of Physical Education, Sports and Life Safety, Tchaikovsky State Physical Education and Sport Academy, Tchaikovsky, Russia.

Vladimir A. Vetrov, Candidate of Pedagogical Sciences, Research Fellow, Scientific and Medical Center, Tchaikovsky State Physical Education and Sport Academy, Tchaikovsky, Russia.

Emilia K. Ryabova, Research Fellow, Scientific and Medical Center, Tchaikovsky State Physical Education and Sport Academy, Tchaikovsky, Russia.

Информация об авторах

Зебзеев Владимир Викторович, доктор педагогических наук, профессор, проректор по научной работе, Чайковская государственная академия физической культуры и спорта, Чайковский, Россия.

Вулич Марина, магистр наук, PhD, специалист интернальной медицины, отделение интернальной медицины, центр здоровья Вракар, Белград, Сербия.

Зданович Ольга Сергеевна, кандидат педагогических наук, доцент, кафедра теории и методики физической культуры, спорта и безопасности жизнедеятельности, Чайковская государственная академия физической культуры и спорта, Чайковский, Россия.

Ветров Владимир Александрович, кандидат педагогических наук, научный работник, научно-медицинский центр, Чайковская государственная академия физической культуры и спорта, Чайковский, Россия.

Рябова Эмилия Константиновна, научный работник, научно-медицинский центр, Чайковская государственная академия физической культуры и спорта, Чайковский, Россия.

Contribution of the authors:

The authors contributed equally to this article.

The authors declare no conflict of interests.

Вклад авторов:

Все авторы сделали эквивалентный вклад в подготовку публикации.

Авторы заявляют об отсутствии конфликта интересов.

The article was submitted 16.09.2025

Статья поступила в редакцию 16.09.2025