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SOMATOTYPE MAGNITUDE IN ASSOCIATION WITH NUTRITIONAL INTAKE AMONG LITHUANIAN PROFESSIONAL ROAD CYCLISTS

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Annotation. Optimal nutrition goals are undoubtedly associated with general health, fitness, and somatotype in athletes. The primary aim of this single cross-sectional study was to determine the somatotype profiles in relation to nutritional profiles among Lithuanian high-performance road cyclists (n = 50). The nutritional status of athletes and body composition along with the somatotype profiles were performed using a battery of both the 3-day food record analysis and the multiple frequency bioelectrical impedance analysis (BIA). The central tendency values for the somatotype components of endomorphy, mesomorphy and ectomorphy in male and female athletes playing cycling sports were 4.3–5.1–3.5 and 4.2–4.4–3.2, respectively. In the athletes' cohort under analysis, high-level mesomorphs were prone to consume low-carbohydrate (β –0.1, 95% confidence interval (CI): –0.1; –0.01, p = 0.036) and high-protein diets (β 0.3, 95% CI: 0.2; 0.6, p = 0.047). Contrastingly, the professional road cyclists with a higher expression of ectomorphy were on high-carbohydrate (β 0.1, 95% CI: 0.01; 0.2, p = 0.049) diet. Finally, although nutrition goals as a mediator can play a key role in undergoing the maintenance of balance between the optimal body composition for athletic performance and the development of an ecto-mesomorphic somatotype, the professional male cyclists with higher levels of mesomorphy value should be aware of lowering the body fat percentage coupled with dietary fat reduction and higher protein plus carbohydrates intakes. Also, the somatotyping as an additional assessment approach can be utilized in choosing correct coaching techniques.

Keywords: athletes; body composition; cycling sports; nutrition; somatotype

INTRODUCTION

In the United States, the term somatotype was introduced by psychologist W. H. Sheldon and incorporated into a system for classifying human body types. According to the somatotype classification system, individuals are categorized based on three core components: endomorphs (rounded), mesomorphs (muscular), and ectomorphs (slender) (Oluwaseyi et al., 2024). Today, somatotyping remains an important factor influencing not only physical fitness but also overall health.

While scientific literature presents varying perspectives on the potential influence of different somatotypes on sports success, the development of a body type, together with factors such as training regimen, nutrition that promotes adaptation to physical loads, and psychological preparedness, is particularly important for ensuring a successful athletic career, encapsulating the notion that an "athlete is both born and made" (Tanner et al., 1960).

It is noteworthy that the application of anthropometry is crucial for athlete selection (for example, forming a prospective Olympic cohort) and for continuously monitoring physical performance parameters at later stages of development. Thus, to comprehensively assess athletes' body fat, muscle, and mineral distribution, and to identify the dominant somatotype, periodic evaluation of body composition has become highly significant in sports medicine. Assessing athletes' body composition and somatotype helps reveal the interaction between genetic factors and specific physiological and metabolic demands, which in turn depend on the nature of physical activity and corresponding nutritional requirements.

Somatotype assessment can be particularly useful for athletes in sports where body type may influence the effectiveness of specific movements (Massidda et al., 2013; Vucetić et al., 2008). During training, athletes representing various sports also modify individual body characteristics, such as body mass and upper and lower limb proportions (Gutnik et al., 2015). Therefore, in optimizing athlete development programs, somatotype research and anthropometric measurements of specific body segments have become increasingly important, as the dynamics of certain body shape developments depend on the specificity of the sport practiced.

Scientific findings support the influence of the practiced sport on somatotype expression, showing that athletes tend to be more mesomorphic and less endomorphic. However, somatotypes can vary depending on the sport. For example, a higher expression of the mesomorphic component has been observed in combat athletes, weightlifters, swimmers, and rowers (Kutseryb et al., 2017; Lewandowska et al., 2011).

Meanwhile, the somatotype of high jumpers more often corresponds to a balanced ectomorph (Kutseryb et al., 2017), whereas athletes in cyclic sports most commonly exhibit an ecto-mesomorphic somatotype (Seydalieva & Khairullaeva, 2024).

There is scientific evidence suggesting an association between somatotype and nutritional status. For example, previous studies (Gordon et al., 1987) reported a relationship between endomorphy and elevated blood cholesterol levels. In addition, depending on carbohydrate intake, endomorphs exhibit increased sensitivity to insulin secretion (Elliot, 2020). Therefore, a low-glycemic diet is recommended for endomorphs to better control blood glucose levels while ensuring adequate intake of dietary protein. In contrast, mesomorphs, compared to ectomorphs, are more prone to both skeletal

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muscle hypertrophy and body fat accumulation. For this reason, a protein-rich diet may be advisable for mesomorphs (Penggalih & Solichah, 2019). Finally, ectomorphs tend to have more intense lipolysis, allowing them to reduce body fat more quickly. Accordingly, a diet high in carbohydrates with increased protein and fat content is recommended for ectomorphs (Villaroman, 2022). However, in athlete populations, there is still insufficient scientific data on the possible associations between dominant somatotype and macronutrient intake (Raschka & Graczyk, 2013).

Thus, considering that a well-developed anthropometric profile may determine an athlete's suitability for high-performance sports (Bamondes-Avila et al., 2023; Kastrati et al., 2023; Samodra et al., 2023; Shahidi et al., 2023; Slankamenac et al., 2021), there remain gaps in research regarding the relationship between macronutrient intake and somatotype development, particularly among professional road cyclists.

The aim of this study is to determine the associations between dominant somatotype development and macronutrient consumption in professional road cyclists from the Lithuanian Olympic cohort.

MATERIALS AND METHODS

An analytical cross-sectional study was conducted at the Lithuanian Sports Centre during the macrocycle's preparatory competition period. The study involved road cyclists aged 18.7 ± 3.1 years, with an average training experience of 6.6 ± 4.1 years, training on average 5.5 ± 0.9 times per week for 186.7 ± 78.3 minutes per day (n = 50). The sample consisted of 62% men (n = 31) and 38% women (n = 19).

Using a bioelectrical impedance analysis (BIA) method with body composition analysis equipment (X-Scan, Kyungsan City, Republic of Korea), athletes' body composition was assessed, including standing height (cm), body mass (kg), body water (kg and %), fat-free mass (kg and %), muscle mass (kg and %), and fat mass (kg and %).

Based on validated equations reported in the literature (Bertuccioli et al., 2022; El Dimassi et al., 2023; Peterson et al., 2016; VanItallie et al., 1990) and using BIA results, predictive values for the main somatotype components (endomorphy, mesomorphy, ectomorphy) were calculated as follows:

1. Endomorphy (men) = 10.44 − 0.0297 × height (m) − 0.0683 × body water (%) + 0.150 × BMI (kg/m²)
2. Endomorphy (women) = 4.313 − 0.0572 × body water (%) + 0.145 × BMI (kg/m²)
3. Mesomorphy (men) = 11.81 − 0.0524 × height (m) − 0.00725 × Rz (Ω) + 0.230 × BMI (kg/m²); where Rz is intracellular water resistance measured at 1000 kHz and equal to 314.97 Ω
4. Mesomorphy (women) = 8.91 − 0.0589 × height (m) − 0.00395 × Rz (Ω) + 0.317 × BMI (kg/m²); where Rz is intracellular water resistance measured at 1000 kHz and equal to 314.97 Ω
5. Ectomorphy (men) = −60.25 + 0.188 × height (m) + 0.0146 × Rz (Ω) − 0.350 × body water (kg) + 0.345 × body water (%) + 0.4174 × BMI (kg/m²) + 0.105 × edema index (EI); where Rz is intracellular water resistance measured at 1000 kHz and equal to 314.97 Ω, and EI corresponds to the ratio of intracellular water to total body water
6. Ectomorphy (women) = −2.119 + 0.119 × body water (%) + 0.0778 × muscle mass (%) + 0.244 × BMI (kg/m²) − 0.709 × fat-free mass index (kg/m²)

In the later stages of the study, athletes were classified according to their somatotype profiles using the Heath-Carter method (Carter, 2022). Based on "low," "medium," "high," and "very high" levels of endomorphy, mesomorphy, and ectomorphy, the calculated values could range as follows: 0.5–2.5, 2.5–5, 5–7, and ≥7 (Carter, 2022). It should be noted that an individual does not have only one somatotype value; therefore, the results report all three body type components according to their degree of expression. For example, a somatotype value of 4.1–5.3–2.7 corresponds to endomorphy = 4.1, mesomorphy = 5.3, and ectomorphy = 2.7. Overall, based on body type scores, six somatotype profiles characteristic of athletes were identified: "endomorphic mesomorph," "balanced mesomorph," "ecto-mesomorph," "meso-ectomorph," "mesomorphic ectomorph," and "balanced ectomorph" (Baranauskas et al., 2024; Campa et al., 2020).

To determine nutrient intake, a three-day 24-hour dietary recall was conducted at the Lithuanian Sports Centre. During direct interviews, using a food and dish photo atlas (Barzda et al., 2007), a sports dietitian recorded all foods and dishes consumed by each athlete. From these data, average daily food intake was calculated for each athlete. Using the NutriSurvey software (SEAMEO-TROPMED RCCN – University of Indonesia) with integrated food composition tables (Nutrition Surveys and Calculations, 2010), the chemical composition of the diets was calculated. Specifically, the average daily energy and macronutrient intake (carbohydrates, protein, fat) was estimated (Sučilienė and Abaravičius, 2002). Macronutrient intake in the cyclists was evaluated according to recommended guidelines in the literature (Baranauskas et al., 2025; Maughan et al., 2018), with recommended intake ranges of 5–8 g/kg/day for carbohydrates, 1.2–2.2 g/kg/day for protein, and 25–35% of total energy from fat.

Statistical data analysis was conducted using SPSS (Statistical Package for Social Sciences) v.25.0 (Armonk, NY, USA). The Shapiro-Wilk test was used to assess data normality. Arithmetic means and standard deviations (SD) were calculated for data analysis. Somatotype development between male and female subgroups was compared using the Student's t-test for independent samples. Differences were considered statistically significant at $p \leq 0.05$.

In the final stage of data analysis, multiple linear regression was applied to determine which macronutrients (independent variables) predicted athletes' somatotype expression (dependent variable). The R^2 coefficient of determination was calculated to assess the adequacy of the three multiple regression models (models were considered acceptable if $R^2 > 0.25$). Regression coefficients (β ± standard errors (SE)) and their 95% confidence intervals (CI) were computed. Linear regression models were adjusted to control for athletes' biological sex.

RESULTS AND DISCUSSION

According to the study data, the height, body mass, and muscle mass of male and female road cyclists were as follows: men – 180 ± 7 cm, 71.1 ± 7.9 kg, 77.8 ± 3.8%, and women – 169 ± 4 cm, 60.5 ± 6.9 kg, 71.2 ± 3.7%, respectively. Regardless of sex, the cyclists' muscle mass remained within normal ranges.

Assessment of body fat percentage showed that men's fat mass (16.3 ± 3.8%) slightly exceeded the optimal range (by ~2.3% compared to 14%), whereas women's body fat percentage (23.0 ± 3.7%) fell within the recommended range (20–24%). More detailed information on athletes' height and body composition is presented in Table 1.

Table 1

Standing height and body composition of road cyclists (n = 50)

Standing height and body composition	Males (n = 31)	Females (n = 19)	Norm
Standing height (cm)	180 ± 7	169 ± 4	—
Body weight (kg)	71.1 ± 7.9	60.5 ± 6.9	—
Total body water (kg)	42.7 ± 3.8	33.4 ± 3.2	M: 55–65%, F: 45–60%
Total body water (%)	60.3 ± 2.8	55.4 ± 2.7	
Lean body mass (kg)	59.3 ± 5.3	46.5 ± 4.4	M: 75–85%, F: 70–80%
Lean body mass (%)	83.7 ± 3.8	77 ± 3.8	
Muscle mass (kg)	55.1 ± 4.9	43 ± 4.1	M: 74–80%, F: 64–80%
Muscle mass (%)	77.8 ± 3.8	71.2 ± 3.7	
Body fat (kg)	11.8 ± 3.5	14.1 ± 3.5	M: 10–14%, F: 20–24%
Body fat (%)	16.3 ± 3.8	23 ± 3.7	

Note: M—males, F—females.

As shown in Table 2, the energy intake of the cyclists' diets (men: 52 kcal/kg/day; women: 41 kcal/kg/day) met daily energy requirements. Carbohydrate and protein intake for men and women ranged from 5.7–6.4 g/kg/day and 1.5–1.8 g/kg/day, respectively. These levels were consistent with recommendations and sufficient to meet the cyclists' needs for these macronutrients.

Furthermore, analysis of the quantitative composition of major nutrients revealed an excess of dietary fat in male cyclists' diets (36.6% of energy intake). In contrast, female cyclists' fat intake (31.6% of energy intake) remained within the recommended range (25–35% of energy intake).

Table 2

Nutritional profile in elite road cyclists (n = 50)

Macronutrients	Males (n = 31)	Females (n = 19)	RDI
Energy intake (kcal/day)	3600 ± 895	2381 ± 1076	—
Energy intake (kcal/kg/day)	52 ± 15	41 ± 22	—
Carbohydrates (g/kg/day)	6.4 ± 2,2	5.7 ± 3.7	5–8
Carbohydrates (% of energy intake)	49.4 ± 5,8	53 ± 9.9	45–55
Protein (g/kg/day)	1.8 ± 0,6	1.5 ± 0.6	1.2–2.2
Protein (% of energy intake)	14 ± 2.2	15.3 ± 4.1	15–20
Fat (% of energy intake)	36.6 ± 5,4	31.6 ± 9.3	25–35

Note: RDI—The recommended daily intake.

Based on the data presented in Table 3, due to higher mesomorphic and endomorphic indices, the road cyclists' somatotype corresponded to the endomorphic mesomorph category. Detailed analysis confirmed that the average values of the main somatotype components for male and female cyclists—endomorphy, mesomorphy, and ectomorphy—were 4.3–5.1–3.5 and 4.2–4.4–3.2, respectively.

Additionally, the mesomorphic component in male cyclists was significantly higher compared to female cyclists (5.1 ± 0.4 vs. 4.4 ± 0.5; $p < 0.001$).

Table 3

The categorization of road cyclists with different levels of the magnitude of each of the three somatotype components depending on sex

Somatotype component	Males (n = 31)	Females (n = 19)	*p*
Endomorphy	4.3 ± 0,4	4.2 ± 0.4	0.570
Mesomorphy	5.1 ± 0,4	4.4 ± 0.5	<0.001
Ectomorphy	3.5 ± 0,6	3.2 ± 0.5	0.081
Somatotype categories	Endomorphic mesomorph	Endomorphic mesomorph	

Note: *p*—*p*–value.

In the next stage of data analysis, three multiple linear regression models were developed to examine the associations between macronutrient intake and the development of the main somatotype components in cyclists, adjusting for athletes' sex (Table 4).

The multiple linear regression analysis revealed that a higher mesomorphy index in cyclists was positively associated with greater protein intake (β = 0.3, 95% CI: 0.2; 0.6, p = 0.047) and negatively associated with carbohydrate intake (β = –0.1, 95% CI: –0.1; –0.01, p = 0.036). Conversely, a higher ectomorphy index was positively associated with increased carbohydrate intake (β = 0.1, 95% CI: 0.01; 0.2, p = 0.049) in this sample of professional road cyclists (Table 4).

Table 4

Association between nutritional intake and somatotype components magnitude in professional road cyclists

Independent variables	**β ± SE**	**95% CI [LB; UB]**	***p***
Endomorphy			
Carbohydrates (g/kg/day)	–0.1 ± 0.01	[–0.1; –0.01]	0.039
Protein (g/kg/day)	0.02 ± 0.2	[–0.3; 0.3]	0.889
Fat (g/kg/day)	–0.03 ± 0.1	[–0.3; 0.2]	0.800
Mesomorphy			
Carbohydrates (g/kg/day)	–0.1 ± 0.03	[–0.1; –0.01]	0.036
Protein (g/kg/day)	0.3 ± 0.02	[0.2; 0.6]	0.047
Fat (g/kg/day)	–0.1 ± 0.1	[–0.3; 0.2]	0.661
Ectomorphy			
Carbohydrates (g/kg/day)	0.1 ± 0.03	[0.01; 0.2]	0.049
Protein (g/kg/day)	–0.2 ± 0.2	[–0.6; 0.3]	0.473
Fat (g/kg/day)	0.2 ± 0.2	[–0.2; 0.5]	0.360

Note: A representation of multiple linear regression models (dependent variables were the somatotypes of athletes: endomorphs, mesomorphs, and ectomorphs; independent variables: the intake (g/kg of body weight per day) of macronutrients, namely, carbohydrates, proteins, and fat). The linear regression models were adjusted for the athletes' sex. SE—standard error, LB—lower bound, UB—upper bound, CI—confidence interval, *p*—*p*–value.

In summary, the somatotype analysis of the endurance athlete cohort (road cyclists) identified a predominance of mesomorphy, associated with well-developed skeletal muscle mass. In this study, mesomorphy indices ranged from 4.4 to 5.1 in both male and female subgroups. These findings, indicating relatively high mesomorphy among Lithuanian professional road cyclists, are consistent with previously published data from Lithuania (Gutnik et al., 2015), Poland (Hagner-Derengowska et al., 2014), India (Hraste, 2023), Spain (Alacid et al., 2015), Uzbekistan (Seydalieva & Avezova, 2024), Czech Republic (Siriški & Novotný, 2015), and Mexico (Martínez-Cervantes et al., 2018), reporting mesomorphy indices in aerobic athletes ranging from 4.8 to 5.1.

According to this study, the mesomorphy component was positively associated with protein intake and negatively associated with carbohydrate intake in professional road cyclists. This can be explained by the fact that protein- and amino acid–rich foods, with or without carbohydrates, are optimal for promoting skeletal muscle hypertrophy during intensive and/or prolonged physical activity (e.g., post-resistance training) (Bukhari et al., 2015; Greenhaff et al., 2008; Kerksick et al., 2018).

Furthermore, since mesomorphs—unlike ectomorphs—have a higher potential for both muscle hypertrophy and fat gain, endurance athletes should be aware of the benefits of consuming foods higher in carbohydrates and lower in fats (Villaroman, 2022). In this context, the study also observed a slightly elevated body fat percentage, likely due to excess dietary fat intake in male cyclists with relatively high mesomorphy indices.

Research suggests that the ectomorphic mesomorph subtype is most favorable for athletes (Carter & Heath, 1990). Continuous physical activity in ectomorphs can enhance calorie expenditure, stimulate lipolysis, and/or suppress glucose uptake. Therefore, given the study's finding of a positive association between higher carbohydrate intake and increased ectomorphy in cyclists, the authors recommend that ectomorphs consume more carbohydrates while maintaining recommended protein and fat intake (Villaroman, 2022).

CONCLUSIONS

The dominant somatotype developed in Lithuanian professional road cyclists corresponded to the endomorphic mesomorph, reflecting a well-organized athlete training process in which relatively high muscle mass is developed through training, but lower body fat is not fully achieved, particularly in the male cyclist subgroup.

Regression analysis indicated a positive association between higher mesomorphy and ectomorphy indices and protein and carbohydrate intake, respectively. Additionally, higher mesomorphy was associated with lower carbohydrate consumption.

Considering that endurance road cyclists may benefit more from a well-developed ectomorphic mesomorph subtype, a key recommendation is to increase carbohydrate and protein intake while reducing high-fat dietary habits.

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These findings could serve as a pioneering reference for optimizing the training of high-level cyclists, suggesting that somatotype assessment, integrated with body composition analysis and actual dietary evaluation, can be a valuable tool in athlete monitoring and individualized training optimization.

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