Central European Journal of Sport Sciences and Medicine

a quarterly journal

University of Szczecin
Faculty of Health
and Physical Education

Vol. 51, No. 3/2025

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025
ISSN (print): 2300-9705 | ISSN (online): 2353-2807

Contents

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025: 5–20
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-01

EXAMINING THE RELATIONSHIP BETWEEN SPORTS ACTIVITIES, NUTRITIONAL STATUS AND SLEEP HABITS IN CHILDREN WITH AUTISM SPECTRUM DISORDER

Ayşe Nur Kahve[A, B, D]
Department of Sports and Health, Aksaray University, Aksaray, Turkey
ORCİD: 0000-0001-6960-7204 | e-mail: aysenurkahve@aksaray.edu.tr

Yağmur Yıldız[B]
Department of Sports and Health, Aksaray University, Aksaray, Turkey
ORCİD: 0000-0001-6852-2364

Hande Yazıcıoğlu Çalışan[A, B]
Department of Sports and Health, Aksaray University, Aksaray, Turkey
ORCİD: 0000-0002-6100-9880

Ali Rıza Atıcı[C]
Department of Sports and Health, Aksaray University, Aksaray, Turkey
ORCİD: 0000-0001-9983-4213

Okan KAMİŞ[C]
Department of Sports and Health, Aksaray University, Aksaray, Turkey
ORCİD: 0000-0002-5640-7833

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Abstract This study aimed to assess the influence of sports activities on certain nutritional habits, eating issues, food consumption frequencies, and sleep patterns in children with autism, categorized by age groups. This study was cross-sectional and included 93 children between the ages of 3 and 18 years, divided according to participation in sports activities three days a week within autism sports clubs and associations. The investigation employed various tools, including nutrition habit inquiries, a food consumption frequency questionnaire, and the Children's Sleep Habits Questionnaire (CSHQ) Short Form. The findings revealed that children engaged in sports exhibited a higher consumption rate of egg compared to their non-participant counterparts. Moreover, when examining the sleep patterns of children with autism across different ages, it was observed that non-participating children aged 3–5 years had significantly higher CSHQ scores than their sporting counterparts aged 3–5 ($p < 0.05$; $d = 1.71$). This study suggests that involvement in sports activities may serve as a promising strategy for regulating the nutritional intake and sleep patterns of children with autism, thereby potentially enhancing overall sleep quality.

Key words: autism spectrum disorder, CSHQ, eating behaviours, sleep problems

Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder characterized by symptoms such as social-emotional challenges, difficulties in non-verbal communication, repetitive behaviors, restricted interests, sensory sensitivities, and rigid adherence to routines (American Psychiatric Association, 2013). According to the Centers for Disease Control and Prevention (CDC), the prevalence rate of children with autism is 1 in 36. Data from North America, Europe and Asia indicate that the average prevalence is around 1–2% (Centre for Disease Control and Prevention, 2018). Additionally, the prevalence ratio of autism between males and females is reported to be approximately 5:1 (Werling & Geschwind, 2013).

Autism diagnosed children frequently show unhealthy eating behaviours as compared to their peers who are normally developing (Marí-Bauset et al., 2014). Among these behaviors, there is often food selectivity, with a tendency to consume high-energy-dense foods more while consuming fewer fruits and vegetables compared to their typically developing peers (Sharp et al., 2013). These behaviors can persist into adolescence or adulthood. It can lead to an increase in unhealthy body weight and associated health outcomes as a result of imbalanced nutritional intake (Dhaliwal et al., 2019). It has been shown that highly selective eating habits are not necessarily associated with appetite loss in autism diagnosed children, and many parents have reported that their children demonstrate a healthy appetite for foods they enjoy (Cermak et al., 2010). These foods often contain highly processed foods (Hubbard et al., 2014). The consumption of nutrient-poor, energy-dense foods and beverages compared to healthier options may contribute to excessive weight gain in autism diagnosed children.

Autism diagnosed children have a fourfold higher risk of obesity (Broder-Fingert et al., 2014). Children with autism are more than three times more likely to develop metabolic syndrome than neurotypically developing children (Messiah et al., 2015). Children with autism and their families often face various challenges associated with the physical inactivity caused by autism (Healy et al., 2019). Research indicates that individuals with ASD, in addition to the core symptoms of ASD, are at risk of experiencing various issues, including medical and psychiatric conditions (Healy et al., 2018), excessive body weight or obesity (Curtin et al., 2014), sleep disorders (Calhoun et al., 2020), physical inactivity (Liang et al., 2020), motor abnormalities and disorders (Chu et al., 2020) and executive function disorders (Sachse et al., 2013). Exercise is one of the promising compensatory methods that can positively affect cognitive functions from early childhood (Carson et al., 2016) to adulthood (Prakash et al., 2015) and can be used to reduce the risk of age-related cognitive impairment (Erickson et al., 2019) is increasingly emerging (Hirata et al., 2016; Richdale & Schreck, 2009).

There are many internal factors that can influence children's sleep (Borbély et al., 2016). Among the internal factors are age, gender, existing illnesses such as a developmental disorder, obstructive sleep apnea, or the sleep disorder itself, and habits like complementary sleep and exercise. More than 80% of children with neurodevelopmental disorders experience sleep disturbances. Specifically, children with autism spectrum disorder may encounter difficulties not only in staying asleep but also in falling asleep (Blackmer & Feinstein, 2016; Kotagal & Broomall, 2012; Souders et al., 2009).

In the literature, there are studies comparing exercise interventions in children and adolescents with ASD to typically developing children, and there are also studies focusing solely on the impact of exercise on sleep quality (Hirata et al., 2016) or dietary habits (Mendive Dubourdieu & Guerendiain, 2022; Shaly & Sreesna, 2013) in individuals with ASD. To the best of our knowledge, there is no research identified that specifically examines the sleep and dietary habits of children with ASD based on their engagement in sports and categorization into age groups. Therefore, the aim of this study is to examine the impact of sports activities on the dietary and sleep habits of children with ASD by comparing them across different age groups.

Material and Methods

Participants and Study Design

The study utilized a cross-sectional research design, where participants were contacted and the questionnaire was administered only once. Our study group was formed by categorizing 93 children aged 3–18 years, who are members of autism sports clubs and autism associations. The age-based categorization in our study was carefully selected based on developmental psychology and pediatric literature, which indicate that children with autism spectrum disorder (ASD) exhibit significant changes in behavioral, cognitive, and physiological patterns as they grow. Participants who exercised for at least 150 min/week (engage in sports three times a week) were included in the "sports" group, while those performing <150 min/week were included in the "non-sports" group. To be included, participants had to be between the ages of 3 and 18 years old, diagnosed with ASD, and have a parental consent form.

The exclusion criteria for the study included children with diagnoses other than Autism Spectrum Disorder, individuals over the age of 18 years, and children who incompletely filled out the data collection tools. A total of 121 individuals were reached; however, 14 children were excluded due to having a diagnosis other than autism, 13 children were excluded because they were over 18 years old, and 1 child was excluded due to incomplete filling out of the data collection tools. The ethical principles of the Helsinki Declaration were taken into consideration in the study. Before commencing the study, an informed consent form was shared with families and educators. Additionally, ethical approval was obtained from the Aksaray University Human Research Ethics Committee with the letter dated 20.06.2023 and numbered E-34183927-000-00000838482.

Data Collection Tools

The surveys and scales used in the study were created in a computerized format and administered through Google Forms. Descriptions regarding the applied surveys and scales were provided. Data collection took place between June 2023 and September 2023.

Socio-demographic data; were obtained through a 13-item questionnaire prepared by the research team. In these questions, data such as the child's age, height, weight, gender, parents' ages, and educational backgrounds have been queried.

Food Frequency Questionnaire Survey (FFQ); queried the participants about their general dietary patterns and the frequency of consuming various food groups, taking into consideration the overall nutrition patterns of the participating children. The validation study of the survey was conducted by Guneş et al. (2016).

The Children's Sleep Habits Questionnaire Short Form (CSHQ); was developed by Owens et al. (2000) in the year 2000 to investigate children's sleep habits and related issues (Owens et al., 2000). The Children's Sleep Habits Questionnaire-Short Form consists of a total of 33 items. The scale defines a total of eleven sub-dimensions, including difficulty waking up in the morning, parasomnias related to sleep fragmentation, sleep anxiety, sleep-related breathing disturbance, other parasomnias, waking up in the morning, sleep duration, sleep onset, the need to sleep with others, daytime sleepiness, and bedwetting at night. The items in the scale are evaluated on a 3-point

Likert system. The cut-off score of the scale is 41. A high total CSHQ score indicates poor sleep quality (Owens et al., 2000).

Statistical analysis

The statistical analysis of the data obtained in the research was conducted using the SPSS 26.0 (Statistical Package for Social Sciences) statistical software package. Categorical variables are presented with the count (n) and percentage (%), while numerical variables are provided with the mean (X) and standard deviation (SD) values. Before analyzing the data, the skewness and kurtosis values of the data were checked. Fisher exact test was used for the variable of food consumption frequencies according to the sports participation status of children with autism. An independent samples t-test was employed for the assessment of sleep habits between the groups of those who engage in sports and those who do not. The significance level for the analyses was set at 0.05. Cohen's d value was calculated to determine the effect size. Cohen's effect sizes were interpreted as follows: $d < 0.2$: trivial, $d < 0.5$: small effect, $d < 0.8$: medium effect, and $d > 0.8$: large effect. (Cohen, 1988).

Results

Sociodemographic Characteristics of Children with Autism

The sociodemographic characteristics of the children with autism included in the study, categorized by age groups within the 3–18 age range, are presented in Table 1. In our study, 29.4% of the participants are female, while 79.6% are male children with autism.

Table 1. Some Sociodemographic Characteristics of Children with Autism by Age Groups

Sociodemographic Characteristics		3–5 n (%)	6–8 n (%)	9–11 n (%)	12–14 n (%)	15–18 n (%)
Gender	Female 19 (20.4)	1 (6.2)	5 (21.7)	4 (28.5)	5 (18.5)	4 (30.7)
	Male 74 (79.6)	15 (93.7)	18 (78.2)	10 (71.4)	22 (81.4)	9 (69.2)
Height	$\bar{X}$	111.1	123.2	140.6	157.4	167.5
	Min–max	85–120	100–150	120–165	130–184	135–188
Body weight	$\bar{X}$	19.4	26.0	40.5	56.4	66.8
	Min–Max	12–30	16–52	26–76	26–100	45–85
Number of Children in the Family	1 Child	5 (31.2)	7 (30.4)	3 (21.4)	7 (25.9)	3 (23.0)
	2 Children	5 (31.2)	10 (43.4)	4 (28.5)	11 (40.7)	5 (38.4)
	3 Children	3 (18.7)	6 (26.0)	4 (28.5)	8 (29.6)	2(15.3)
	4 Children and Above	3 (18.7)	–	3 (21.4)	1 (3.7)	3 (23.0)
Age (Mother)	<25	–	–	–	3 (11.1)	–
	25–35	8 (50.0)	10 (43.4)	2 (14.2)	2 (7.4)	2 (15.3)
	>35	8 (50.0)	13 (56.5)	12 (85.7)	22 (8.1)	11(84.6)

Age (Father)	<25	–	–	–	–	–
	25–35	4 (25.0)	7(30.4)	1 (7.1)	1 (3.7)	–
	>35	12(75.0)	16 (69.5)	13 (92.8)	26 (96.3)	13 (100)
Education (Mother)	Postgraduate	1 (6.2)	3 (13.0)	1 (7.1)	1 (3.7)	2 (15.3)
	Undergraduate	6 (37.5)	8 (34.7)	4 (28.5)	11 (40.7)	6 (46.1)
	High School	4 (25.0)	8 (34.7)	5 (35.7)	10 (37.0)	4 (30.7)
	Primary School	4 (25.0)	4 (17.3)	3 (21.4)	5 (18.5)	1 (7.6)
	Non completed Primary school	1 (6.2)	–	1 (7.1)	–	–
Education (Father)	Postgraduate	2 (12.5)	4 (17.3)	–	1 (3.7)	2 (15.3)
	Undergraduate	3 (18.7)	6 (26.0)	4 (28.5)	13 (48.1)	5 (38.4)
	High School	5 (31.2)	9 (39.1)	5 (35.7)	7 (25.9)	5 (38.4)
	Primary School	6 (37.5)	4 (17.3)	5 (35.7)	6 (22.2)	1 (7.6)
Employment Status (Mother)	Working	4 (25.0)	6 (26.0)	3 (21.4)	7 (25.9)	2 (15.4)
	Non Working	12 (75.0)	17 (73.9)	11 (78.6)	20 (74.0)	11 (84.6)
Employment Status (Father)	Working	15 (93.7)	21 (91.3)	12 (85.7)	26 (96.3)	1 (3.7)
	Non Working	1 (6.2)	2 (8.7)	2 (14.3)	10 (76.9)	3 (23.1)

Dietary Habits of Children with Autism

The dietary habits of children with autism included in the study, categorized by age groups within the 3–18 age range, are presented in Table 2. When the number of meals consumed by children with autism was examined, it was found that the rate of consuming three meals per day was 80.9% for those who engaged in sports three days a week, and 76.4% for those who did not engage in sports three days a week. Among children with autism, 28.57% of those who participate in sports three times a week skip snacks while 33.33% of children with autism who do not engage in sports three days a week skip snacks. When examining the place of eating, 7.1% of children with autism engaged in sports and 11.7% of those not engaged in sports prefer eating while moving.

When examining the issues related to the quantity of food and beverage consumed by children with autism, 4.7% of those engaging sports and 9.8% of those non sports were observed to consume smaller bites and sips than normal. When evaluating the problems encountered by children with autism during meals, it was determined that 7.1% of those sports and 17.6% of those non sports experience difficulty in chewing and swallowing food (Table 2).

Table 2. Dietary Habits of Children with Autism Based on Their Participation in Sports

3–5 n (%)		Sports n = 42					Non–sports n = 51				
		6–8 n (%)	9–11 n (%)	12–14 n (%)	15–18 n (%)	3–5 n (%)	6–8 n (%)	9–11 n (%)	12–14 n (%)	15–18 n (%)	
Number of meals per day	1 meal	–	–	–	–	–	1 (6.2)	–	1 (7.1)	–	–
	2 meal	1 (6.2)	2 (8.7)	–	4 (14.8)	1 (7.6)	4 (25)	3 (13.0)	–	1 (3.7)	1 (7.6)
	3 meal	4 (25.0)	11 (47.8)	5 (35.7)	6 (22.2)	8 (61.5)	6 (37.5)	7 (30.4)	8 (57.1)	15 (55.5)	3 (23.0)

Number of skipped meals	Morning	2 (14.2)	3 (16.6)	1 (7.1)	1 (5.8)	2 (18.1)	1 (7.1)	1 (5.5)	3 (21.4)	1 (5.8)	2 (18.1)
	Lunch	2 (14.2)	2 (11.1)	–	3 (17.6)	3 (27.2)	4 (28.5)	5 (27.7)	2 (14.2)	4 (23.5)	1 (9.0)
	Evening	–	1 (5.5)	–	–	–	–	–	1 (7.1)	–	–
	Snack	–	3 (16.6)	4 (28.5)	3 (17.6)	2 (18.1)	5 (35.7)	3 (16.6)	3(21.4)	5 (29.4)	1(9.0)
Reasons for skipping meals	Due to forgetting or not finding the opportunity	1 (7.1)	1 (5.8)	1 (7.6)	3 (17.6)	3 (30.0)	2 (14.2)	–	1 (7.6)	2 (11.7)	1 (10.0)
	Because of not wanting to	3 (21.4)	6 (35.2)	4 (30.7)	3 (17.6)	3 (30.0)	8 (57.1)	7 (41.1)	6 (46.1)	7 (41.1)	3 (30.0)
	Because of not being hungry	–	2 (11.7)	–	1 (5.8)	–	–	1 (5.8)	1 (7.6)	1 (5.8)	–
Place of eating	At the table	4 (25.0)	10 (43.4)	4(28.5)	9 (33.3)	8 (61.5)	8 (50.0)	7 (30.4)	5 (35.7)	13 (48.1)	3 (23.0)
	On the floor	–	2 (8.7)	–	1 (3.7)	1 (7.6)	–	2 (8.7)	3 (21.4)	2 (7.4)	–
	Standing up	–	–	–	–	–	1 (6.2)	–		–	1 (7.6)
	While walking	1 (6.2)	1 (4.3)	1 (7.1)	–	–	2 (12.5)	1 (4.3)	1 (7.1)	2(7.4)	–
Eating style	Granular	–	3 (13.0)	1 (7.1)	1 (3.7)	1 (7.6)	5 (31.2)	2 (8.7)	2 (14.2)	4 (14.8)	–
	Puree	–	–	–	–	–	–	–	–	–	–
	Liquid	1 (6.2)	–	1 (7.1)	–	1 (7.6)	2 (12.5)	–	–	–	–
	All	4 (25.0)	10 (43.4)	3 (21.4)	9 (33.3)	7 (53.8)	4 (25.0)	8 (34.7)	7 (50.0)	13 (48.1)	4 (30.7)
Person Feeding the Child	**Self Feeding**	3 (18.7)	6 (26.0)	1 (7.1)	5 (18.5)	6 (46.1)	3 (18.7)	5 (21.7)	5 (35.7)	13(48.1)	2 (15.3)
	Mother	–	2 (8.7)	1 (7.1)	–	–	2 (12.5)	5 (21.7)	1 (7.1)	–	–
	Sometimes self. sometimes mother	2 (12.5)	4 (17.3)	3 (21.4)	5 (18.5)	3 (23.0)	6 (37.5)	–	3 (21.4)	3 (11.1)	1 (7.6)
	With the help of other family members	–	1 (4.3)	–	–	–	–	–	–	1 (3.7)	1 (7.6)
Problems with the amount of food and beverages	**None**	4 (25.0)	11 (47.8)	3 (21.4)	8 (29.6)	4 (30.7)	5 (31.2)	8 (34.7)	7 (50.0)	12(44.4)	–
	Very serious restrictive eating	–	1 (4.3)	1 (7.1)	–	–	2 (12.5)	1 (4.3)	–	–	–
	Very large bites and sips	1 (6.2)	–	–	2 (7.4)	5 (38.4)	3 (18.7)	–	–	4 (14.8)	4 (30.7)
	Very small bites and sips	–	1 (4.3)	1 (7.1)	–	–	1 (6.2)	1 (4.3)	2 (14.2)	1 (3.7)	–

Problems Encountered During Feeding	**None**	5 (31.2)	11 (47.8)	4 (28.5)	6 (22.2)	5 (38.4)	8 (50.0)	9 (39.1)	7 (50.0)	8 (29.6)	1 (7.6)
	Vomiting	–	–	–	–	–	–	–	–	–	–
	Rumination	–	–	–	–	1 (7.6)	–	1 (4.3)	–	–	—
	Pica	–	–	–	–	–	–	–	–	–	–
	Spitting out food	–	1 (4.3)	–	1 (3.7)	–	–	–	–	–	–
	Food pouching	–	–	–	–	–	–	–	1 (7.1)	1 (3.7)	–
	Swallowing without chewing	–	–	–	–	3 (23.0)	1 (6.2)	–	–	5 (18.5)	3 (23.0)
	Talking persistently about food	–	–	–	–	–	–	–	–	–	–
	Playing with food	–	–	–	3 (11.1)	–	–	–	–	1 (3.7)	–
	Multiple problems	–	1 (4.3)	1 (7.1)	–	–	2 (12.5)	–	1 (7.1)	2 (7.4)	–

When the frequency of food consumption among autistic children was evaluated, it was found that the rate of daily consumption of milk and dairy products was 52.3% for children who engage in sports, whereas the rate for children who do not engage in sports is 45.1%. When vegetable and fruit consumption was examined, daily consumption rates were higher in children who engage in sports. However, this difference was not found to be statistically significant ($p > 0.05$). The daily egg consumption rate for children who engage in sports is 61.9%, whereas it is 37.2% for children who do not engage in sports. This difference is statistically significant ($p < 0.05$) (Table 3).

Table 3. Food Consumption Frequencies of Children with Autism According to Their Sports Activity

Food Groups	**Sports n = 42**				**Non–Sports n = 51**				
	None n %	**everyday n %**	**1–2 times/week n %**	**1 times/ month n %**	**None n %**	**everyday n %**	**1–2 times/ week n %**	**1 times/month n %**	**p**
Dairy products (Yogurt, Kefir etc.)	8 19.0	22 52.3	12 28.5	– –	16 31.3	23 45.1	10 19.6	2 3.9	.684
Meat Products (fish, chicken, offal, etc.)	7 16.6	14 33.3	21 50.0	–	9 17.6	12 23.5	27 52.9	3 5.8	.238

Egg	8 19.0	26 61.9	6 14.2	2 4.7	13 25.4	19 37.2	16 31.3	3 5.8	**.049***
Legumes (beans, chickpeas, lentils, etc.)	7 16.6	13 30.9	21 50.0	1 2.3	15 29.4	7 13.7	24 47.0	5 9.8	.100
Vegetable	6 14.2	17 40.4	16 38.1	3 7.1	16 31.3	15 29.4	19 37.2	1 1.9	.108
Fruit	3 7.1	33 78.5	5 11.9	1 2.3	9 17.6	30 58.8	9 17.6	3 5.8	.182
Bread and Cereal (pasta, rice, etc.)	1 2.3	31 73.8	9 21.4	1 2.3	2 3.9	38 74.5	9 17.6	2 3.9	.921
Oil (butter, oil, walnuts, almonds, olives)	3 7.1	27 64.2	8 19.0	4 9.5	11 21.5	30 58.8	8 15.6	2 3.9	.448

Fisher's exact test, *p < 0,05

Evaluating the Sleep Patterns of Children with Autism

When the sleep status of children with autism was examined according to their age, the CSHQ score of 3–5 year old children who did non-sports was found to be 49.54 ±8.09, which was significantly higher than that of 3–5 year old children who did sports ($p < 0.05$; $d = 1.71$). In contrast to this situation, the average scores of 12–14 year old children participating in sports on the CSHQ were found to be 50.1 ±8.33, and this was significantly higher than those of 12–14 year-old children who did non-sports ($p < 0.05$; $d = 0.98$) (Table 4).

Table 4. Comparison of CSHQ Total Scores in Children with Autism Based on Their Engagement in Sports Activities

Age Group	Sports n = 42		Non–sports n = 51		t	p	Effect Size
	CSHQ X̄ ±SD	CSHQ Median (Min–Max)	CSHQ X̄ ±SD	CSHQ Median (Min–Max)			
3–5 (n = 16)	39.4 ±2.0	39 (37–42)	49.5 ±8.0	47 (40–62)	–2.715	**0.017**	1.71
6–8 (n = 23)	43.3 ±4.5	45 (36–51)	43.1 ±6.3	41 (36–57)	0.091	0.928	0.03
9–11 (n = 14)	51.8 ±15.3	46 (37–74)	48.6 ±6.4	50 (38–56)	0.544	0.596	0.26
12–14 (n = 27)	50.1 ±8.3	50 (39–61)	41.5 ±8.8	41 (31–65)	2.456	**0.021**	0.98
15–18 (n = 13)	44.2 ±12.5	38 (33–67)	45.2 ±8.9	42 (39–58)	–0.146	0.887	0.09

When the sleep habits of children with autism were evaluated according to their engagement in sports activities, no significant difference was observed between the groups ($p > 0.05$). However, children who did not participate in sports had higher CSHQ average scores in terms of sleep onset delay, sleep duration, and nighttime awakenings compared to children engaged in sports (Table 5).

Table 5. Comparison of Subscale Groups of Sleep Habits in Children with Autism Based on Their Engagement in Sports Activities

CSHQ Subscales	Sports (n = 42)	Non Sports (n = 51)	t	p	Effect Size
	CSHQ X̄ ±SD	CSHQ X̄ ±SD			
Bedtime resistance	10.6 ±3.2	10.0 ±3.3	0.738	0.462	0.17
Sleep onset delay	1.6 ±0.7	1.6 ±0.7	–0.052	0.958	0.01
Sleep duration	3.9 ±1.3	4.0 ±1.2	–0.160	0.873	0.04
Sleep anxiety	6.7 ±2.0	6.6 ±2.3	0.292	0.771	0.06
Night wakings	3.8 ±1.1	4.3 ±1.5	–1.884	0.063	0.33
Parasomnias	8.7 ±2.5	8.6 ±1.9	–0.208	0.836	0.02
Sleep–disordered breathing	3.8 ±1.2	3.6 ±0.9	1.021	0.310	0.21
Daytime sleepiness	10 ±2.6	9.7 ±2.7	0.420	0.675	0.08
Mean Scale Scores	45.6 ±9.4	45.1 ±8.2	0.285	0.776	0.05

Discussion

Irregular feeding behavior limited physical activity and sleep disturbances are all risks that threaten healthy living in children with ASD (Curtin et al., 2014; Dhaliwal et al., 2019; Matheson & Douglas, 2017; Srinivasan et al., 2014). It is undeniable that researchers need more studies that comprehensively describe the lifestyle factors of children with ASD. Within this scope, some eating habits, nutritional problems, food consumption frequencies, and sleep habits of children with ASD have been assessed.

It is known that the risk of experiencing nutritional problems in children with autism is significantly higher (approximately five times) compared to their peers (Sharp et al., 2013). Findings from recent studies suggest that problems such as being selective towards a particular food or food group, showing sensitivity, and rejecting food often result in various nutritional issues, leading to eating behavior disorders and inadequate nutrient intake (Berding & Donovan, 2016).

When studies investigating eating habits in children with autism are evaluated, the habit of having three main meals is common (Kaynar & Yılmaz, 2020; Şengüzel et al., 2021, Shaly & Sreesna, 2013). When we examined the meal frequencies of the children with autism included in our study, the rate of consuming three meals for those engaged in sports was found to be 80.9%, while the rate for those not engaged in sports was 76.4%. Of the children with autism who engage in sports three days a week, 28.57% skip snacks. In comparison, 33.33% of children with autism who do not engage in sports three days a week skip snacks (Table 2). A study found that, 38% of children with ASD require assistance from their parents while eating, and 30% can eat on their own (Bicer & Alsaffar 2013), In our study, it was observed that 52.68% of children with autism can eat on their own, while 47.32% require assistance while eating. The inclusion of children with a lower age range may have an impact on the lower percentage. It is generally accepted that many children with ASD have unique food preferences and unusual eating behaviors (Schreck & Williams, 2006).

It has been also shown that regular exercises applied to children with autism have positive behavioral, cognitive and social effects (Hynes & Block, 2023). It is generally known that many children with ASD have unique food preferences and unusual eating behaviors (Schreck & Williams, 2006). In our study, it was observed that children with ASD who practiced sports 3 days a week had lower rates of very severely limited eating, very large bites and sips, and very small bites and sips compared to children who did not practice sports 3 days a week (Table 2). Our study is consistent with the view that sports activities have a significant relationship with oral motor skills.

According to a study addressing the feeding problems of children with ASD, the most common problem, with a rate of 30%, was found to be the children's food choices. Of the participating children with autism, 24% were reported to eat quickly, and 24% to eat excessively. The rates for difficulty transitioning to table meals, gagging/coughing during meals, and refusing meals were observed as 17%, 17%, and 16%, respectively (Zeybek & Yurttagül, 2020). In another study, it was found that 45% of children with ASD vomit during meals, and 56% retain food in their mouths (Siddiqi et al., 2019). In our study, vomiting during meals was not observed. Food retention in the mouth was observed in 2.15% of children with ASD. None of the children with autism participating in our study exclusively consumed pureed food, and it was observed that 5.37% of them consumed only liquid food. Children with ASD were found to have a high probability of accepting only low-texture foods, such as pureed foods. Researchers have concluded that children with autism exhibit significantly greater food selectivity compared to typically developing children (Zeybek & Yurttagül, 2020). In our study, 74.19% of children with ASD consume all types of food. In the study conducted Demir and Ozcan (2022) involving children with ASD and a control group, it was shown that 71.2%

of children with ASD ate at the table, while 91% of the control group ate at the table. This difference was found to be statistically significant. In our study, 76.3% of children with ASD eat their meals at the table.

In a study on the frequency of food consumption in children with autism, it was observed that 57.1% of the children reject vegetables, and 32.1% reject fruits (Zeybek & Yurttagül, 2020). In a conducted study, it was found that children with ASD consume fewer vegetables, fruits, and dairy products compared to their typically developing peers (Sharp et al., 2013). In a study examining the frequency of food consumption among children with ASD aged 2–13 in India, it was found that the consumption of fruits, green leafy vegetables, and other vegetables was low, while the consumption of grains (mainly white and brown rice) was high. Additionally, it was determined that milk consumption is infrequent (Siddiqi et al., 2019). A meta-analysis study also reported that children with autism consume lower levels of fruits and vegetables (Esteban-Figuerola et al., 2019). In our study, the daily consumption rates of vegetables and fruits for children who sports were found to be 40.47% and 78.58%, respectively. The daily fruit and vegetable consumption rates of children with autism who non sports were found to be 29.4% and 58.8%, respectively. In a study, the daily egg consumption of children with autism was 37.01 ±55.37 g, while it was 27.37 ±18.79 g for children with typical development, but the result did not show a statistically significant difference (Mendive Dubourdieu et al., 2022). In another epidemiological study, the daily egg consumption of preschool children with autism was 12.15 g, while it was 17.79 g in typically developing children (Canals-Sans et al., 2022). In our study, when the egg consumption frequency of children with autism was examined, the daily egg consumption rate of children who sports was 61.9%, while the daily egg consumption rate of children with autism who did not do sports was found to be 37.2% (Table 3). Most research has focused on non-disabled children (Zhu et al., 2024; Tournier et al., 2024). This results in a deficiency of research on effective interventions for children with autism. This gap limits the opportunity to reduce health risks related to nutrition in the population. The understanding and increased feasibility of adequate and balanced nutrition according to parents of children with autism will contribute to improving the quality of life and prevent public health issues.

Physical activity, children's nutrition, and sleep habits are recognized as promising approaches for improving sleep quality. Research has shown that participation in physical activity has a positive impact on the health, sleep patterns, and overall quality of life of individuals with ASD (Liang et al., 2024). Recently, most research has emphasized the importance of practices that promote sports for individuals with ASD. It was reported that sports may have a positive effect on the health, sleep patterns, and quality of life of individuals with ASD. It has been also observed that improvement in sleep quality has a positive effect on individuals' problematic behaviors, and improvements in cognitive-executive dimensions and motor functions (Cohen et al., 2014; Gómez et al., 2020).

In a study conducted on 40 children with autism aged 6–14 years, participants in the experimental group practiced water-based activities for 2 sessions/60 minutes per week for 10 weeks and it was concluded that these activities can improve sleep quality in children (Sikora et al., 2012). In another study conducted on 6 children with autism between the ages of 4–13 years, 30 minutes of in-water exercise was applied to children and no statistically significant difference was found between sleep quality between nights with and without exercise (Wilson, 2019). In our study, the mean CSHQ score of children with ASD aged 3–5 years who practiced sports 3 days a week was found to be significantly lower than children with ASD aged 3–5 years who did not practice sports 3 days a week, while the mean CSHQ score of children aged 12–14 years who practiced sports 3 days a week was found to be higher ($p < 0.05$, ES = 0.98) (Table 4). Although this situation partially contradicts the literature, it may be due to the difficulty of observing 12–14-year-old children accurately because the data were collected through parents.

Our study provides concrete data in terms of observing the score difference by giving the CSHQ score of each age group according to sportive activities. In one study, researchers aimed to compare the sleep quality and quality of life of children who participated in regular physical activity and those who did not, and found no significant difference in sleep patterns or sleep habits between the two groups (Seferoğlu & Güral, 2022). Because of the difficulty in estimating when a person has fallen asleep, more and more people have begun to adopt device-based sleep measurements to provide more accurate estimates (Wang et al., 2024).

Individuals with autism in different age groups are more likely to have various sleep disorders and limited sleep duration (Hand et al., 2020; Lugo et al., 2020). In our study, it was concluded that children who did not practice sports 3 days a week had higher mean scores in sleep duration and night awakenings CSHQ compared to children who did practice sports 3 days a week (Table 5). In line with our findings, research has shown that combined aerobic exercise (AET) and motor skills training increased sleep efficiency, shortened the delay in sleep onset, and decreased the awakening time after falling asleep in 63% of the sample in the nights following AET and MS (Brand et al., 2015). Another study examined the effect of physical activity on sleep and behavioral functioning in children aged 8–12 years with autism spectrum disorder and confirmed the benefits of exercise on sleep duration and behavioral functions in children with autism spectrum disorder (Tse et al., 2022). Wachob and Lorenzi (2015) found that children who were more physically active had less difficulty falling asleep and their sleep patterns were less disrupted in 10 children with autism aged 9–16 years. Research has shown that 12-week basketball training for children with autism improves sleep quality (Tse et al., 2022) and a 4-week swimming program reduces the time to fall asleep (Oriel et al., 2016). Therefore, it can be said that there is an important relationship between physical activity and sleeping habits.

Several limitations should be considered when interpreting the results of this study. Initially, the reliance on parent-reported data as the only source for children's sleep and dietary issues, along with contributing factors, presents a potential concern. It is important to acknowledge that parents might either minimize or overstate their children's difficulties in these areas. Furthermore, the accuracy of parental recollections could influence the perceived connection between eating and sleep disturbances. Another constraint is the absence of comparative data from typically developing children or other children with special needs, which limits the ability to contextualize the findings. Additionally, this cross-sectional study design prevents the observation of changes in sleep or eating patterns over time. Finally, the assessment of physical activity levels, which depended on participant memory and self-reporting, introduces a potential for inaccuracies due to recall bias.

Conclusion

The current findings reveal differences in dietary habits, food consumption frequencies, and sleep habits among children with autism based on their engagement in sports activities. Our study shows that participation in sports activities three times per week is associated with a higher frequency of egg consumption and more regular eating habits in children with autism. These findings suggest that involvement in sports activities may serve as a promising strategy for regulating the sleep patterns and nutritional intake of children with autism, thereby potentially enhancing overall sleep quality.

Acknowledgements Special thanks to Başkent Autism, Osem Autism, Marmara Autism, Boğaziçi Autism, Anka Autism, Antalya Autism Association, Bursa Special Children and Life Club, Aksaray Gönül Dostları Education and Rehabilitation Center for their support in conducting our study. We also express our gratitude to all the parents who contributed to this study.

Funding This study has no funding support to declare.

Data availability statement The survey data are accessible to data consumers and researchers worldwide via the Internet.

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.

Ansari, S., AdibSaber, F., Elmieh, A., & Gholamrezaei, S. (2021). The effect of water-based intervention on sleep habits and two sleep-related cytokines in children with autism. *Sleep Medicine*, *82*, 78–83. https://doi.org/10.1016/j.sleep.2021.03.045

Berding, K., & Donovan, S. M. (2016). Microbiome and nutrition in autism spectrum disorder: current knowledge and research needs. *Nutrition Reviews*, *74*(12), 723–736. https://doi.org/10.1093/nutrit/nuw048

Bicer, A. H., & Alsaffar, A. A. (2013). Body mass index, dietary intake and feeding problems of Turkish children with autism spectrum disorder (ASD). *Research in Developmental Disabilities*, *34*(11), 3978–3987. https://doi.org/10.1016/j.ridd.2013.08.024

Blackmer, A. B., & Feinstein, J. A. (2016). Management of sleep disorders in children with neurodevelopmental disorders: a review. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, *36*(1), 84–98. https://doi.org/10.1002/phar.1686

Borbély, A. A., Daan, S., Wirz-Justice, A., & Deboer, T. (2016). The two-process model of sleep regulation: a reappraisal. *Journal of Sleep Research*, *25*(2), 131–143. https://doi.org/10.1111/jsr.12371

Brand, S., Jossen, S., Holsboer-Trachsler, E., Pühse, U., & Gerber, M. (2015). Impact of aerobic exercise on sleep and motor skills in children with autism spectrum disorders–a pilot study. *Neuropsychiatric Disease and Treatment*, 1911–1920. https://doi.org/10.2147/NDT.S85650

Broder-Fingert, S., Brazauskas, K., Lindgren, K., Iannuzzi, D., & Van Cleave, J. (2014). Prevalence of overweight and obesity in a large clinical sample of children with autism. *Academic Pediatrics*, *14*(4), 408–414. https://doi.org/10.1016/j.acap.2014.04.004

Calhoun, S. L., Pearl, A. M., Fernandez-Mendoza, J., Durica, K. C., Mayes, S. D., & Murray, M. J. (2020). Sleep disturbances increase the impact of working memory deficits on learning problems in adolescents with high-functioning Autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *50*, 1701–1713. https://doi.org/10.1007/s10803-019-03928-y

Canals-Sans, J., Esteban-Figuerola, P., Morales-Hidalgo, P., & Arija, V. (2022). Do children with autism spectrum disorders eat differently and less adequately than those with subclinical ASD and typical development? EPINED epidemiological study. *Journal of Autism and Developmental Disorders*, *52*(1), 361–375. https://doi.org/10.1007/s10803-021-04928-7

Carson, V., Hunter, S., Kuzik, N., Wiebe, S. A., Spence, J. C., Friedman, A., Tremblay, M. S., Slater, L., & Hinkley, T. (2016). Systematic review of physical activity and cognitive development in early childhood. *Journal of Science and Medicine in Sport*, *19*(7), 573–578. https://doi.org/10.1016/j.jsams.2015.07.011

Centre for Disease Control and Prevention (CDC). Data & Statistics on Autism Spectrum Disorder (ASD). 2018. Available online: https://www.cdc.gov/ncbddd/autism/data.html (accessed on 21 June 2023)

Cermak, S. A., Curtin, C., & Bandini, L. G. (2010). Food selectivity and sensory sensitivity in children with autism spectrum disorders. *Journal of the American Dietetic Association*, *110*(2), 238–246. https://doi.org/10.1016/j.jada.2009.10.032

Chu, C.-H., Tsai, C.-L., Chen, F.-C., Sit, C. H., Chen, P.-L., & Pan, C.-Y. (2020). The role of physical activity and body-related perceptions in motor skill competence of adolescents with autism spectrum disorder. *Disability and Rehabilitation*, *42*(10), 1373–1381. https://doi.org/10.1080/09638288.2018.1526334

Cohen, J. (1988). The effect size. *Statistical Power Analysis for the Behavioral Sciences*, 77–83. https://cir.nii.ac.jp/crid/1572261550809239040

Cohen, S., Conduit, R., Lockley, S. W., Rajaratnam, S. M., & Cornish, K. M. (2014). The relationship between sleep and behavior in autism spectrum disorder (ASD): a review. *Journal of Neurodevelopmental Disorders*, *6*(1), 1–10. https://doi.org/10.1186/1866-1955-6-44

Curtin, C., Jojic, M., & Bandini, L. G. (2014). Obesity in children with autism spectrum disorders. *Harvard Review of Psychiatry*, *22*(2), 93. https://doi.org/10.1097/HRP.0000000000000031

Demir, A. Ç., & Özcan, Ö. (2022). The nutritional behavior of children with autism spectrum disorder, parental feeding styles, and anthropometric measurements. *Nordic Journal of Psychiatry*, *76*(1), 64–70. https://doi.org/10.1080/08039488.2021.1934109

Dhaliwal, K. K., Orsso, C. E., Richard, C., Haqq, A. M., & Zwaigenbaum, L. (2019). Risk factors for unhealthy weight gain and obesity among children with autism spectrum disorder. *International Journal of Molecular Sciences*, *20*(13), 3285. https://doi.org/10.3390/ijms20133285

Efstratopoulou, M., Sofologi, M., Giannoglou, S., & Bonti, E. (2022). Parental stress and children's self-regulation problems in families with children with autism spectrum disorder (ASD). *Journal of Intelligence*, *10*(1), 4. https://doi.org/10.3390/jintelligence10010004

Erickson, K. I., Hillman, C., Stillman, C. M., Ballard, R. M., Bloodgood, B., Conroy, D. E., Macko, R., Marquez, D. X., Petruzzello, S. J., & Powell, K. E. (2019). Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. *Medicine and Science in Sports and Exercise*, *51*(6), 1242. https://doi.org/10.1249/MSS.0000000000001936

Esteban-Figuerola, P., Canals, J., Fernández-Cao, J. C., & Arija Val, V. (2019). Differences in food consumption and nutritional intake between children with autism spectrum disorders and typically developing children: A meta-analysis. *Autism*, *23*(5), 1079–1095. https://doi.org/10.1177/1362361318794179

Garcia, J. M., Leahy, N., Rivera, P., Brazendale, K., & Rice, D. J. (2020). The association among demographic factors, health behaviors and sleep quality in youth with Autism Spectrum Disorder. Disability and Health Journal, 13(3), 100885.

Gómez, A. G., Morillo, M. M., Sánchez, J. C. Z., & Cotrina, L. J. (2020). Actividad física y sueño en un grupo de tres adolescentes con autismo. *Retos: nuevas tendencias en educación física, deporte y recreación*(38), 248–254. https://doi.org/10.47197/retos.v38i38.74586

Gunes, F. E., Elmacioglu, F., Aktac, S., & Saglam, D. (2016). Development and Validation of a Semi-Quantitative Food Frequency Questionnaire to Assess Dietary Intake of Turkish School-Aged Children [journal article]. *Polish Journal of Food and Nutrition Sciences*, *66*(2), 129–137. https://doi.org/10.1515/pjfns-2015-0029

Hand, B. N., Angell, A. M., Harris, L., & Carpenter, L. A. (2020). Prevalence of physical and mental health conditions in Medicare-enrolled, autistic older adults. *Autism*, *24*(3), 755–764. https://doi.org/10.1177/1362361319890793

Healy, S., Aigner, C. J., & Haegele, J. A. (2019). Prevalence of overweight and obesity among US youth with autism spectrum disorder. *Autism*, *23*(4), 1046–1050. https://doi.org/10.1177/1362361318791817

Healy, S., Nacario, A., Braithwaite, R. E., & Hopper, C. (2018). The effect of physical activity interventions on youth with autism spectrum disorder: A meta‐analysis. *Autism Research*, *11*(6), 818–833. https://doi.org/10.1002/aur.1955

Hirata, I., Mohri, I., Kato-Nishimura, K., Tachibana, M., Kuwada, A., Kagitani-Shimono, K., Ohno, Y., Ozono, K., & Taniike, M. (2016). Sleep problems are more frequent and associated with problematic behaviors in preschoolers with autism spectrum disorder. *Research in Developmental Disabilities*, *49*, 86–99. https://doi.org/10.1016/j.ridd.2015.11.002

Hubbard, K. L., Anderson, S. E., Curtin, C., Must, A., & Bandini, L. G. (2014). A comparison of food refusal related to characteristics of food in children with autism spectrum disorder and typically developing children. *Journal of the Academy of Nutrition and Dietetics*, *114*(12), 1981–1987. https://doi.org/10.1016/j.jand.2014.04.017

Hynes, J., & Block, M. (2023). Effects of physical activity on social, behavioral, and cognitive skills in children and young adults with autism spectrum disorder: A systematic review of the literature. *Review Journal of Autism and Developmental Disorders*, *10*(4), 749–770.

Kaynar, A. N., & Yılmaz, H. Ö. (2020). Otizm spektrum bozukluğu olan çocuklarda beslenme durumunun belirlenmesi. *Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi*, *9*(2), 151–162. https://doi.org/10.37989/gumussagbil.544033

Kotagal, S., & Broomall, E. (2012). Sleep in children with autism spectrum disorder. *Pediatric Neurology*, *47*(4), 242–251.

Liang, X., Li, R., Wong, S. H., Sum, R. K., & Sit, C. H. (2020). Accelerometer-measured physical activity levels in children and adolescents with autism spectrum disorder: A systematic review. *Preventive Medicine Reports*, *19*, 101147. https://doi.org/10.1016/j.pmedr.2020.101147

Liang, X., Haegele, J. A., Tse, A. C. Y., Li, M., Zhang, H., Zhao, S., & Li, S. X. (2024). The impact of the physical activity intervention on sleep in children and adolescents with autism spectrum disorder: A systematic review and meta-analysis. *Sleep Medicine Reviews*, 101913.

Lugo, J., Fadeuilhe, C., Gisbert, L., Setien, I., Delgado, M., Corrales, M., Richarte, V., & Ramos-Quiroga, J. A. (2020). Sleep in adults with autism spectrum disorder and attention deficit/hyperactivity disorder: A systematic review and meta-analysis. *European Neuropsychopharmacology*, *38*, 1–24. https://doi.org/10.1016/j.euroneuro.2020.07.004

Marí-Bauset, S., Zazpe, I., Mari-Sanchis, A., Llopis-González, A., & Morales-Suárez-Varela, M. (2014). Food selectivity in autism spectrum disorders: a systematic review. *Journal of Child Neurology*, *29*(11), 1554–1561. https://doi.org/10.1177/0883073813498821

Matheson, B. E., & Douglas, J. M. (2017). Overweight and obesity in children with autism spectrum disorder (ASD): A critical review investigating the etiology, development, and maintenance of this relationship. *Review Journal of Autism and Developmental Disorders*, *4*(2), 142–156. https://doi.org/10.1007/s40489-017-0103-7

Mendive Dubourdieu, P., & Guerendiain, M. (2022). Dietary intake, nutritional status and sensory profile in children with autism spectrum disorder and typical development. *Nutrients*, *14*(10), 2155. https://doi.org/10.3390/nu14102155

Messiah, S. E., Vidot, D. C., Somarriba, G., Haney, K., Aytur, S., Natale, R. A., Brosco, J. P., & Arheart, K. L. (2015). Obesity and cardiometabolic disease risk factors among US adolescents with disabilities. *World Journal of Diabetes*, *6*(1), 200. https://doi.org/10.4239/wjd.v6.i1.200

Messiah S. E., Vidot D. C., Somarriba G., Haney K., Aytur S., Natale R. A., Brosco J. P., Arheart K. L. Obesity and cardiometabolic disease risk factors among US adolescents with disabilities. World J Diabetes 2015; 6(1): 200–207. https://doi.org/10.4239/wjd.v6.i1.200

Nguyen, T. D. (2022). Potential of Physical Activity-Based Intervention on Sleep in Children with and without Autism Spectrum Disorder. In *Exercise Physiology*. IntechOpen. https://doi.org/10.5772/intechopen.102534

Noor Safiza, M. N., & LeCouteur, A. (2015). Spectrum of feeding problems and gastrointestinal symptoms in children with autism spectrum disorders: A scoping review. *Malaysian Journal of Nutrition*, *21*(1), 105–119.

Oriel, K. N., Kanupka, J. W., DeLong, K. S., & Noel, K. (2016). The impact of aquatic exercise on sleep behaviors in children with autism spectrum disorder: A pilot study. *Focus on Autism and Other Developmental Disabilities*, *31*(4), 254–261. https://doi.org/10.1177/1088357614559212

Owens, J. A., Spirito, A., & McGuinn, M. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep*, *23*(8), 1043–1051. http://europepmc.org/abstract/MED/11145319

Prakash, R. S., Voss, M. W., Erickson, K. I., & Kramer, A. F. (2015). Physical activity and cognitive vitality. *Annual Review of Psychology*, *66*, 769–797. https://doi.org/10.1146/annurev-psych-010814-015249

Richdale, A. L., & Schreck, K. A. (2009). Sleep problems in autism spectrum disorders: prevalence, nature, & possible biopsychosocial aetiologies. *Sleep Medicine Reviews*, *13*(6), 403–411. https://doi.org/10.1016/j.smrv.2009.02.003

Sachse, M., Schlitt, S., Hainz, D., Ciaramidaro, A., Schirman, S., Walter, H., Poustka, F., Bölte, S., & Freitag, C. M. (2013). Executive and visuo-motor function in adolescents and adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *43*, 1222–1235. https://doi.org/10.1007/s10803-012-1668-8

Schreck, K. A., & Williams, K. (2006). Food preferences and factors influencing food selectivity for children with autism spectrum disorders. *Research in Developmental Disabilities*, *27*(4), 353–363. https://doi.org/10.1016/j.ridd.2005.03.005

Seferoğlu, E. G., & Gürol, A. (2022). Sleep habits and quality of life of intellectually disabled children with and without regular physical activity. Sleep, 10(6), 674–682. https://doi.org/10.14235/bas.galenos.2021.6090

Shaly, C., & Sreesna, O. (2013). Nutrient Intake and Food Consumption Pattern of Autistic Children. *IOSR Journal of Nursing and Health Science*, *2*(5), 7–9. https://doi.org/10.1542%2Fpeds.2012-0900L

Sharp, W. G., Berry, R. C., McCracken, C., Nuhu, N. N., Marvel, E., Saulnier, C. A., Klin, A., Jones, W., & Jaquess, D. L. (2013). Feeding problems and nutrient intake in children with autism spectrum disorders: a meta-analysis and comprehensive review of the literature. *Journal of Autism and Developmental Disorders*, *43*, 2159–2173. https://doi.org/10.1007/s10803-013-1771-5

Siddiqi, S., Urooj, A., & D'Souza, M. J. (2019). Dietary patterns and anthropometric measures of Indian children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *49*, 1586–1598. https://doi.org/10.1007/s10803-018-3850-0

Sikora, D. M., Johnson, K., Clemons, T., & Katz, T. (2012). The relationship between sleep problems and daytime behavior in children of different ages with autism spectrum disorders. *Pediatrics*, *130*(Supplement_2), S83–S90. https://doi.org/10.1542/peds.2012-0900f

Souders, M. C., Mason, T. B., Valladares, O., Bucan, M., Levy, S. E., Mandell, D. S., Weaver, T. E., & Pinto-Martin, J. (2009). Sleep behaviors and sleep quality in children with autism spectrum disorders. *Sleep*, *32*(12), 1566–1578. https://doi.org/10.1093/sleep/32.12.1566

Srinivasan, S. M., Pescatello, L. S., & Bhat, A. N. (2014). Current perspectives on physical activity and exercise recommendations for children and adolescents with autism spectrum disorders. *Physical Therapy*, *94*(6), 875–889. https://doi.org/10.2522/ptj.20130157

Şengüzel, S., Cebeci, A. N., Ekici, B., Gönen, İ., & Tatlı, B. (2021). Impact of eating habits and nutritional status on children with autism spectrum disorder. *Journal of Taibah University Medical Sciences*, *16*(3), 413–421. https://doi.org/10.1016/j.jtumed.2020.11.010

Tournier, C., Forde, C. G. (2024). Food oral processing and eating behavior from infancy to childhood: evidence on the role of food texture in the development of healthy eating behavior. *Critical Reviews in Food Science and Nutrition*, 64(26), 9554–9567. https://doi.prg/10.1080/10408398.2023.2214227

Tse, A. C., Lee, P. H., Zhang, J., Chan, R. C., Ho, A. W., & Lai, E. W. (2022). Effects of exercise on sleep, melatonin level, and behavioral functioning in children with autism. *Autism*, *26*(7), 1712–1722. https://doi.org/10.1177/13623613211062952

Wachob, D., & Lorenzi, D. G. (2015). Brief report: Influence of physical activity on sleep quality in children with autism. *Journal of Autism and Developmental Disorders*, *45*, 2641–2646. https://doi.org/10.1007/s10803-015-2424-7

Wang, T., Li, W., Deng, J., Zhang, Q., Liu, Y., & Zheng, H. (2024). The impact of the physical activity intervention on sleep in children and adolescents with neurodevelopmental disorders: a systematic review and meta-analysis. Frontiers in Neurology, 15, 1438786. https://doi.org/10.3389/fneur.2024.1438786

Werling, D. M., & Geschwind, D. H. (2013). Sex differences in autism spectrum disorders. *Current opinion in neurology*, *26*(2), 146. https://doi.org/10.1097%2FWCO.0b013e32835ee548

Wilson, K. E. (2019). The effect of swimming exercise on amount and quality of sleep for children with autism spectrum disorder. Retrieved January 31, 2024, from: http://ideaexchange.uakron.edu/honors_research_projects/986

Zeybek, S. G., & Yurttagul, M. (2020). Nutrient status, diet quality and growth parameters of children with autism spectrum disorder in Northern Cyprus. *Progress in Nutrition,*22(3) Vol. 22, e2020020. https://doi.org/10.23751/pn.v22i3.8847

Zhu, H., Zhao, K., Huang, L., Shi, W., Tang, C., Xu, T., Zhu, S., Xu, Q., Li, X., Chen, Y., Liu, Q., Yang, L. (2024). Individual, family and social-related factors of eating behavior among Chinese children with overweight or obesity from the perspective of family system. *Frontiers in Pediatrics,* 12, 1305770. https://doi.org/10.3389/fped.2024.1305770

Cite this article as: Kahve, A. N., Yildiz, Y., Yazıcıoğlu Çalışan, H., Atici, A. R., & Kamiş, O. (2025). Examining the Relationship Between Sports Activities, Nutritional Status and Sleep Habits in Children with Autism Spectrum Disorder. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 5–20. https://doi.org/10.18276/cej.2025.3-01

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025: 21–31
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-02

ACUTE EFFECTS OF FIVE DIFFERENT STRETCHING EXERCISES ON AGILITY AND SPEED

Hana Kabešová[A,B,C,D,E]

Department of Physical Education and Sport, Faculty of Education, Jan Evangelista Purkyne University in Usti nad Labem, Czech Republic
ORCID: 0000-0002-6653-4078

Lucie Lebrušková[B]

Department of Physical Education and Sport, Faculty of Education, Jan Evangelista Purkyne University in Usti nad Labem, Czech Republic

David Svoboda[B]

Department of Physical Education and Sport, Faculty of Education, Jan Evangelista Purkyne University in Usti nad Labem, Czech Republic

David Cihlář[B,C,D]

Department of Physical Education and Sport, Faculty of Education, Jan Evangelista Purkyne University in Usti nad Labem, Czech Republic

Elena Bendíková[A,D,E]

Department of Physical Education and Sports, Faculty of Education, CU Ružomberok, Slovakia, FIEPS, WLO
ORCID: 0000-0001-5952-056X | e-mail: bendikova.elena@gmail.com

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract The aim of the research was to evaluate the acute effect of five different stretching techniques used as a part of agility and speed training. The sample groups consisted of 108 PF UJEP students who study in the field of physical education and sports. Participants performed five different warm-up stretching models in five different weeks, each Monday at the same time and place. The agility test and sprint were applied immediately after each stretching exercise. Both tests were performed without stretching (NS), after static stretching (SS), dynamic stretching (DS), static + dynamic stretching (SDS), and dynamic + static stretching (DSS) following 5 minutes of jogging. The ANOVA Chi Square statistical method and Wilcoxon Matched Pairs Tests were used to evaluate the data. The differences between the protocols were as follows NS with DS, NS with DSS, NS with SDS, SS with DS, SS with DSS, SS with SDS, DSS with SDS in 10 m ($p < 0.05$). There is a statistical difference between NS with SS, NS with DS, NS with DSS, NS with SDS in Illinois agility test ($p < 0.05$). Types of dynamic stretching have a positive effect on strength and speed sports performance. To increase agility, it is recommended to warm up in combination with a model of dynamic stretching after static stretching.

Key words: agility, stretching, warm-up, speed

Introduction

Warm-up is an integral part of the training and teaching unit when there is an increase of requirement for sports performance. Warm-up is important to increase body temperature and stretching is primarily intended to increase range of motion at a joint or group of joints. Stretching further compensates for one-sided loading, reduces muscle tension, facilitates regeneration after loading and creates a feeling of body relaxation.

There are various types of stretching such as static stretching, dynamic stretching, ballistic (swing stretching), proprioceptive neuromuscular facilitation (PNF) stretching and many of its subtypes. In our research, we deal with static and dynamic stretching, including their combinations. Static stretching is slow stretching of the muscles in the final position up to 60 seconds (Peck et al., 2014; Torres et al., 2008; Young & Behm, 2002). It is necessary to respect gradual stretching with prolonged exhalation and avoid drastic stretching, which is very painful and unwholesome. Mild stretching, when, after taking up the starting position, the muscle is slowly stretched to the appropriate position with a feeling of a slight stretch, is followed by a phase after two to three seconds of releasing the developing stretch, i.e., the second phase continuing the tensile action on the muscle. Dynamic stretching is performed in such a way that the driving force of the movement is the kinetic energy of the body. The movement is carried out in a controlled and conscious manner without maintaining the final position, but there is no swing [4]. The positives of dynamic stretching are that the neural pathways responding to the stretching stress are activated more strongly than with static stretching, the rapid strength in the muscles is better preserved than with static stretching, coordination within the muscle is improved, and the capillaries remain fully open during exercise, while the muscles can be continuously perfused (Kabešová, 2017; Slomka & Regelin, 2008).

Research deals with the question of the influence of warm-up on the performance itself. The issue of the application of stretching as a part of the warm-up before performance is currently a highly discussed topic. A number of studies suggest that dynamic forms of stretching should be preferred over activities that require speed and strength (Aguilar et al., 2012).

Dynamic stretching causes faster contractions of activated muscles and is therefore a prerequisite for faster movements. Muscles produce more force after dynamic stretching due to increased activation of motor units (Behm & Caouachi, 2011). In contrast, a reduced ability to produce force was demonstrated after static stretching, which was due to reduced motor unit activation, or reduced inelasticity of muscle tendon units (Hayes & Walker, 2007). A decrease in the effect on performance occurred after the application of static stretching during the warm-up for running sprint and power endurance performances (Nelson et al., 2005; Nelson & Kokkonene, 2021), for standing long jump and other activities with static force production (Behm & Chaouachi, 2011; Nelson & Bandy, 2005; Nelson & Kokkonene, 2021). It is recommended using a sport-specific warm-up phase method that combines dynamic stretching after static stretching to increase the athlete's speed and agility (Aguilar et al., 2012).

The acute effect of static stretching has a negative effect on agility and sprint performance. This study suggests that dynamic and static + dynamic stretching could be used to achieve better acceleration, speed, and agility performances during warm-up training in young tennis players (Kilit et al., 2017).

Static stretching (SS) shows a decline in many domains, including strength, anaerobic power, and sprint time. Dynamic stretching (DS) shows an increase in anaerobic power and a decrease in sprint time. Research on the effects of stretching on agility performance is limited (Aguilar et al., 2012).

The aim of the study

The aim of the research was to evaluate the acute effect of five different stretching techniques used as a part of agility and speed training. It is assumed that after warming up with dynamic stretching and combinations with dynamic stretching, there will be a relevant improvement in the level of selected tests of agility and speed.

Materials and methods

Participants

The study was attended by 108 healthy and physically active students at the University of Jan Evangelista Purkyně in Ústí nad Labem studying in the field of physical education and sports. The average age of men (n = 72), which was 21.15 + 1.69 years, mean height was 1.80 + 6.25 m and body weight average was 77.52 + 10.05 kg and for women (n = 36) the average age is 21.11 + 2.45 years, mean height 1.68 + 6.28 m and body weight average 61.38 + 5.61 kg.

The criterion for inclusion of the participant in the research was the absence of health problems at the time of the research and regular participation in the research. The students participated voluntarily and confirmed their participation in the study by filling in the informed consent form. Each participant was informed about the procedure and participant´s consent was obtained. If students did not meet the given criteria, they were excluded from the study. All tests were carried out at the same time of day (9 o´clock a.m.) and the implementation took place in five weeks, every Monday from April 2023.

Research design

Participants were informed about the individual steps of the research and were provided with information about the implementation of the test. All actions were carried out under the guidance of the examiner. Testing took place under standard conditions (time, temperature, place) within 5 weeks from April 2023 and the first initial anthropometric assessment.

Participants were informed not to exercise or consume alcohol or caffeine 24 hours before the tests. The stretching warm-up model was performed under the supervision of an expert after a 5-minute warm-up (aerobic jogging of minimum intensity). After each applied model of stretching exercises, the Illinois agility test (s) and a 4 x 10 m (s) shuttle run followed.

The height of the participants was measured using a stadiometer (cm) and body weight was determined using a Tanita scale (kg).

Performance test

Sprint test 4 x 10 m (s) and Illinois agility test (s) were used to determine performance parameters. Information from a controlled interview was used to collect data.

In Figure 1, the Illinois agility test starts at point A, proceeds to point B, and from there zigzags around funnels spaced 3.3 m apart to point C and the test finished at point D (Miller et al., 2006). Test is set up with four cones forming the agility area (10 meters long x 5 meters wide). Cone at point A, marking the start. Cone at B & C to mark the turning spots. Cone at point D to mark the finish. Start lying face down with the hands at shoulder level. On the "go" command, participant begins and time starts when they cross the photocells. Participants should get up and run the course along the set path (left to right or right to left). At the turn spots B and C, they must ensure they touch the cones with their hand. The trial is considered complete when they cross the finish line and no cones have been knocked over.

Sprint test: at the whistle, the participant runs from a semi-high start position from one cone, then the second cone is run around, and the participant returns diagonally to the first cone (so that the track forms a figure eight). After running around, he/she continues to the second cone again, touches it and returns to the start, where he/she must touch the cone again. Each participant first runs the entire course on trial to avoid mistakes. Each proband first runs the entire course on trial to avoid mistakes. Two attempts are made, between which there must be a break of at least 5 min. A better result is noted. Time is measured with an accuracy of 0.1 s. Running path (figure 2) (Pětivlas & Mrázková, 2012).

Stretching exercise protocol

Five types of stretching exercises were used in the following order: non-stretching phase NS, SS (static stretching), DS (dynamic stretching), SDS (static and dynamic stretching) and DSS (dynamic and static stretching).

The non-stretching phase consists of 5 minutes of moderate-intensity aerobic jogging, after which the participants are tested without any other exercise application.

In the SS phase, after a warm-up, i.e., 5 minutes of aerobic jogging, and a cooldown, static stretching followed with eight static exercises targeting the upper and lower limbs and the trunk. The procedure for SS was to take the starting position of the exercise and then stretch with holding time in the extreme position for 30 seconds. The exercise focused on latissimus dorsi (back), pectoralis major (chest), trapezius (neck), rectus abdominis (abdomen), gluteus maximus (hip), quadriceps (front of the leg), hamstring (back of the leg), gastrocnemius (calf) muscle groups.

For DS, the same exercises as in research (Cigerci et al., 2023) were applied: high glute pull, walking lung, light high knees, high knee pull, straight leg kick, carioca, skip A (jumping), skip B (jumping).

In the combination of SS and DS stretching, 8 static exercises with holding time in the extreme position for 30 s were applied, followed by 8 dynamic exercises with 15 s intervals between repetitions. In the combination of DS and SS stretching, the application was reversed. First 8 dynamic stretches were performed with 15 s intervals between repetitions, and then eight static stretches were performed once for 30 seconds at the point of maximal range of motion (Aydin et al., 2019).

Statistical analysis of data

Data were analyzed by analysis of variance (ANOVA) using Statistica software. According to the Shapiro-Wilk normality test, we dealt with non-parametric data and the Wilcoxon test was used to compare the stretching groups. The Wilcoxon test is a non-parametric test used to compare the means of two sets and to determine whether the results of one intervention group are significantly different from the results of the other intervention group. Statistical significance was tested at $p = 0.05$.

The Pearson´s correlation coefficient was used to determine the relationship between the performance achieved in the Illinois test and the sprint test in men, women and all participants with the same type of warm-up.

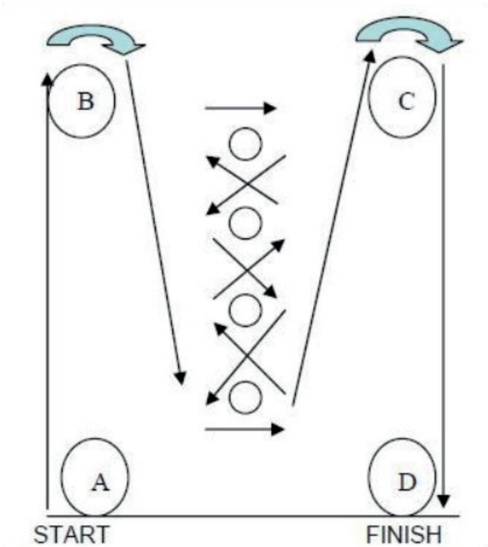


Figure 1. Illinois Agility Test (Miller et al., 2006).

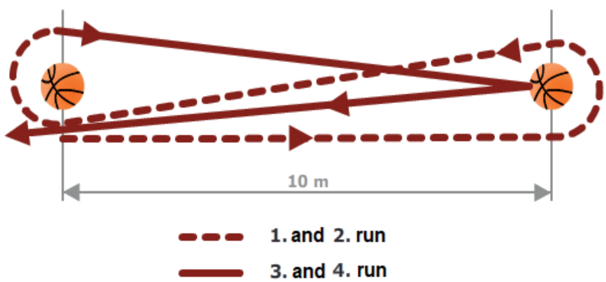


Figure 2. Sprint test 4 x 10 m (Pětivlas & Mrázková, 2012).

Results

In order to use adequate statistical procedures, we first monitored the normality of the variables using the Shapiro-Wilk test. We can state that the monitored quantities have a frequency distribution other than normal, so we will use non-parametric statistical procedures.

The following results present statistically significant differences for individual types of warm-up for the Illinois test. Based on the results of Friedman ANOVA and Kendall Coeff. of Concordance, individual types of stretching in the Illinois test are statistically significant (ANOVA Chi Sqr. (N = 108, df = 4) = 44.75 p < 0.00000; Coeff. of Concordance = 0.10361 Aver. rank r = 0.09523). Table 1 contains the comparison of individual stretching exercise protocols for the results of the Illinois test (p < 0.05). For the results of the Illinois Agility test, there is a statistical difference between NS & DS, NS & DSS, NS & SDS, SS & DS, SS & DSS and SS & SDS ($p < 0.05$). DS proved to be the most effective, followed by SDS (Figure 3).

Table 1. Comparison of individual types of warm-ups for the Illinois test (N=108)

Type of Stretching	Median (s)	Vs. type of Stretching	Median (s)	Z	p-level
No Stretching	16.89	Static Stretching	16.54	1.58	0.11
		Dynamic Stretching	15.95	4.75	0.00
		Dynamic Stretching + Static Stretching	16.45	3.35	0.00
		Static Stretching + Dynamic Stretching	16.27	4.50	0.00
Static Stretching	16.54	Dynamic Stretching	15.95	4.56	0.00
		Dynamic Stretching + Static Stretching	16.45	2.49	0.01
		Static Stretching + Dynamic Stretching	16.27	3.31	0.00
Dynamic Stretching	15.95	Dynamic Stretching + Static Stretching	16.45	0.91	0.36
		Static Stretching + Dynamic Stretching	16.27	0.73	0.46
Dynamic Stretching + Static Stretching	16.45	Static Stretching + Dynamic Stretching	16.27	2.84	0.00

Wilcoxon Matched Pairs Test (*p < 0.05)

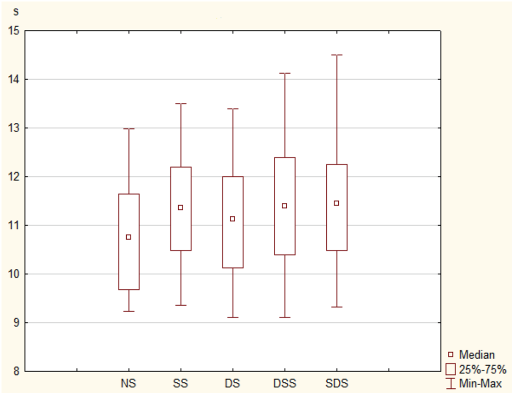
Table 2. Comparison of individual types of warm-up for Sprint test 4 x 10 m (N=108)

Type of Stretching	Median (s)	Vs. type of Stretching	Median (s)	Z	p-level
No Stretching	10.74	Static Stretching	11.35	5.27	0.00
		Dynamic Stretching	11.13	2.99	0.00
		Dynamic Stretching + Static Stretching	11.45	4.49	0.00
		Static Stretching + Dynamic Stretching	11.45	4.93	0.00
Static Stretching	11.35	Dynamic Stretching	11.13	1.53	0.12
		Dynamic Stretching + Static Stretching	11.45	0.48	0.62
		Static Stretching + Dynamic Stretching	11.45	0.66	0.50
Dynamic Stretching	11.13	Dynamic Stretching + Static Stretching	11.45	0.95	0.33
		Static Stretching + Dynamic Stretching	11.45	1.81	0.06
Dynamic Stretching + Static Stretching	11.45	Static Stretching + Dynamic Stretching	11.45	0.75	0.45

Wilcoxon Matched Pairs Test (*p < 0.05)

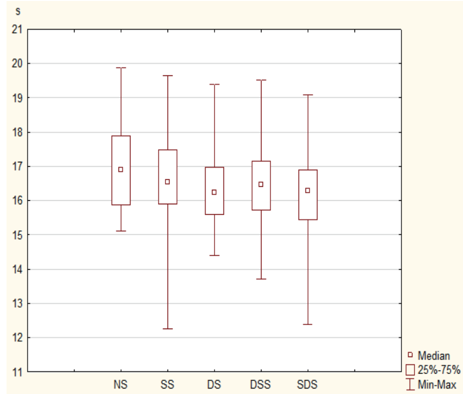
In the shuttle run test, significant differences were also demonstrated for individual types of exercise (ANOVA Chi Sqr. (N = 108, df = 4) = 33.44 $p < 0.00000$; Coeff. of Concordance = 0.07742 Aver. rank r = 0.06880). Table 2 contains the comparison of individual stretching exercise protocols for the results of the shuttle run ($p < 0.05$). The results of the 10 m sprint test showed statistically significant differences between selected types of warm-ups NS & SS, NS & DS, NS & DSS and NS & SDS ($p < 0.05$).

The medians and min and max values are clearly shown in box graphs for both tests (Figure 3, Figure 4), where dynamic stretching appears to be the most effective stretch (Figure 3).



Note: Stretching; NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching.

Figure 3. Box graph – Illinois test.



Note: Stretching; NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching.

Figure 4. Box graph – Sprint test 10 m.

The results in table 3 present a direct relationship between the achieved performances in the Illinois test and the sprint test for men, women and all participants with the same type of warm-up ($p < 0.05$).

Table 3. Rank correlation for men (n = 72), women (n = 36) and total (N = 108)

Stretching	Men			Women			Total		
	R	t(N-2)	p-level	R	t(N-2)	p-level	R	t(N-2)	p-level
NSIL vs. NSCL	0.34	0.34	0.00	0.32	1.99	0.05	0.60	7.77	0.00
SSIL vs. SSCL	0.21	0.21	0.06	-0.12	-0.68	0.50	0.22	2.36	0.01
DSIL vs. DSCL	0.32	0.32	0.00	0.08	0.47	0.64	0.32	3.51	0.00
DSSIL vs. DSSCL	0.42	0.41	0.00	0.31	1.88	0.06	0.44	5.11	0.00
SDSIL vs. SDSCL	0.36	0.36	0.00	0.38	2.46	0.01	0.40	4.49	0.00

NS: No Stretching; SS: Static Stretching; DS: Dynamic Stretching; SDS: Static Stretching + Dynamic Stretching; DSS: Dynamic Stretching + Static Stretching; IL: Illinois test; CL: Sprint test. *$p < 0.05$
Pearson´s correlation coefficient (*$p < 0.05$)

Discussion

The study looked at the effect of five different types of stretching after warming up before exercise on the results of motor tests of speed and agility.

Table 1 shows that different protocols of stretching exercises have a statistically significant effect on the values of the Illinois test ($p < 0.05$). It was found that the best results were obtained with dynamic stretching and combined models with dynamic stretching ($p < 0.05$). Moreover, it is understood that the combined models of stretching exercises performed worse than dynamic stretching but better than static stretching. The study supporting our research (Cigerci et al., 2023) studied the acute effects of five different stretching protocols applied during the warm-up phase on speed and agility. Different stretching exercise protocols have a statistically significant effect on Illinois Agility and Reactive Agility values ($p < 0.05$). It was found that the best results were obtained with dynamic stretching, and there was also a significant difference in favour of dynamic stretching between dynamic stretching and other protocols ($p < 0.05$). Combined stretching exercise models, on the other hand, seem to achieve worse results than dynamic stretching but better than static stretching.

Table 2 shows that different protocols of stretching exercises have a statistically significant effect on the values of the 10 m sprint test ($p < 0.05$). It was found that the best results were obtained with no stretching. There was a significant difference in favor of DS among other protocols ($p < 0.05$). Moreover, it is understood that the combined models of stretching exercises performed worse than dynamic stretching but better than static stretching. The results of the study (Cigerci et al., 2023) showed that different stretching exercise protocols have a statistically significant effect on 10 m and 20 m running values ($p < 0.05$). It was determined that the best results were obtained with dynamic stretching and there was a significant difference in favour of dynamic stretching between dynamic stretching and other protocols ($p < 0.05$). In addition, it is understood that the combined stretching exercise models achieved worse results than dynamic stretching but better than static stretching.

Looking at the literature, although static stretching applied during the warm-up process has been reported to negatively affect agility, many studies show that static stretching increases flexibility (Aydin et al., 2019; O´Sullivan et al., 2009; Samson et al., 2012). Static stretching exercises have been reported to improve flexibility; flexibility can increase athletic performance and speed up recovery (Colby, 2007). In addition to this information, it should not be ignored in the literature that providing flexibility can protect athletes from injury (Gibson et al., 2019). The finding that the acute effect of static stretching has a negative effect on agility and sprint performance suggests that dynamic and static + dynamic stretching could be used to achieve better acceleration, speed, and agility performances during warm-up training in tennis players (Kilit et al., 2017).

The effects of static stretching after a dynamic warm-up on speed, agility and strength were investigated in a study involving male university students participating in team sports (Bishop & Middleton, 2013). Interestingly, the results showed that a routine with a combination of dynamic warm-up and static stretching led to a decrease in average performance in all performance measures; 20 m sprint and agility according to the Illinois test (Bishop & Middleton, 2013). Many researchers have shown that static stretching can limit strength, power, and speed (Bradley et al., 2006; Power et al., 2004; Samuel et al., 2008; Sayers et al., 2008; Steward et al., 2007; Yamaguchi & Ishii, 2005).

Results of the study (Miri-Khorasani et al., 2016) evaluating the acute effect of different warm-up stretching methods on the acceleration and speed of soccer players after different warm-up procedures using 10- and 20-meter tests. There were also significant differences between combined stretching compared to static stretching and no stretching protocol.

Result of the study (Van Gelder & Bartz, 2011) evaluating the effect of static stretching and dynamic stretching on performance time in an agility test. These results suggest that compared to static and no stretching, dynamic stretching significantly improves performance in closed agility skills that involve.

The important factor is the total duration of each stretching exercise, not the number of repetitions in which the exercise is performed. The results of the study suggest that short-term static stretching (<30 seconds) can indeed improve acute speed performance (Avloniti et al., 2016).

Research aimed to evaluate the effects of different lengths of dynamic stretching on speed and agility in female gymnasts to compare how different lengths of dynamic stretching affect performance in these areas. From the results of the study, it can be conc concluded that dynamic stretching has a positive effect on speed and agility in female gymnasts. Shorter stretching protocols (20 and 30 seconds) appear to be most effective for improving gymnastic performance (Dallas et al., 2019).

Results of researching the acute effect of static stretching, dynamic exercise, and a combination of static stretching and dynamic exercise before a sporting event on performance in the vertical jump, medicine ball throw, 10-yard sprint, and running speed in the shuttle run test in teenage athletes (15.5 ±0.9 years old) suggest that before a sporting event it can be for teenage athletes, who engage in performance activities, dynamic exercise or static stretching followed by dynamic exercise more beneficial than static stretching alone (Faigenbaum et al., 2006).

The aim (McMillian et al., 2006) was to compare the effects of dynamic warm-up with the effects of static stretching on selected indicators of strength and agility in cadets (14 women and 16 men aged 18–24 years from the United States Military Academy). Data analysis showed that after dynamic warm-up, participants had better performance scores in all three strength and agility tests ($p < 0.01$) compared to static stretching and no warm-up ($p < 0.01$). Dynamic warm-up methods are effective in improving performance (Fletcher & Anness, 2007; Hought et al., 2009; Little & Williams, 2006; Taylor et al., 2009; Young et al., 2004), but they are not as effective in increasing static flexibility compared to static stretching (Covert et al., 2010; O´Sullivan et al., 2009).

Conclusions

According to the information obtained from the studies, it can be said that the types of stretching performed during the pre-exercise warm-up can affect the performance of athletes. Small increases in athletes' performance can sometimes reveal big differences that can affect competition results. Therefore, it is considered that attention should be paid to the selection of the types of stretching that will be applied in the warm-up section, taking into account the needs of the sports sector and the athlete. Dynamic types of stretching should be preferred over activities that require speed and strength. On the other hand, it is undoubtedly important to increase the athlete's flexibility during these challenging movements and prevent injuries. For this reason, in order to increase the speed and agility of the athlete, a dynamic stretching method can be recommended as part of the warm-up, or a model of a combination of static stretching followed by dynamic stretching.

Funding: This research Effect of Application of Five Stretching Techniques on Speed and Agility, grant number 43 212 15 2005 – 43 01, the research was funded by PF UJEP in Usti nad Labem.

Conflicts of interest: The authors declare no conflict of interest.

References

Aguilar, A. J., DiStefano, L. J., Brown, C. N., Herman, D. C., Guskiewicz, K. M., & Padua, D. A. (2012). A dynamic warm-up model increases quadriceps strength and hamstring flexibility. *J Strength Cond Res*, *26*(4), 1130–1141. https:/doi.org/10.1519/JSC.0b013e31822e58b6

Avloniti. A., Chatzinikolaou, A., Fatouros, I. G., Protopapa, M., Athanailidis, I., Avloniti, C., Leontsini, D., Mavropalias, G., & Jamurtas, A. Z. (2016). The effects of static stretching on speed and agility: One or multiple repetition protocols. *Eur J Sport Sci*, *16*(4), 402–408. https:/doi.org/10.1080/17461391.2015.1028467

Aydın, Y., Kafkas, A., Çınarlı, F. S., Eken, Ö., Kurt, C., & Kafkas, M. E. (2019). Farklı germe egzersizi protokollerinin bazı anaerobik motorik testler üzerine akut etkileri. *Sport Hekimliği Dergisi*, *54*(2), 99–107. https:/doi.org/10.5152/tjsm.2019.121

Behm, D. G., & Caouachi, A. (2011). A review of the acute effects of static and dynamic stretching on Performance. *Eur J App Physiol, 111*(11), 2633–2651. https:/doi.org/10.1007/s00421-011-1879-2

Bishop, D. C., & Middleton, G. (2013). Effects of static stretching following a dynamic warm-up on speed, agility, and power. *J Hum Sport and Exerc*, *8*(2), 391–400. https:/doi.org/10.4100/jhse.2012.82.07

Bradley, P. S., Olsen, P. D., & Portas, M. D. (2006). The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *J Strength Cond Res*, *21*(1), 223–226. https://doi.org/10.1519/00124278-200702000-00040

Cigerci, A. E., Genz, H., Gurses, V. V., Sever, O., & Kizilbag, O. (2023). Acute effects of five different stretching exercise protocols on speed and agility. *Vir Rev Educ Física*, *12*(1), 52–67.

Colby, C. A. (2007). Therapeutic exercise: foundations and techniques. F. A. Davis Company.

Covert, C. A., Alexander, M. P., Petronis, J. J., & Davis, D. S. (2010). Comparison of ballistic and static stretching on hamstring muscle length using an equal stretching dose. *J Strength Cond Res, 24*(11), 3008–3014. https://doi.org/10.1519/jsc.0b013e3181bf3bb0

Dallas, G., Theodorou, A., & Paradisis, G. (2019). The effect of different duration of dynamic stretching on sprint run and agility test on female gymnast. *J Phys Edu Sport, 19*, 268–272.

Faigenbaum, A. D., Kang, J., McFarland, J., Bloom, J. M., Magnatta, J., Ratamess, N. A., & Hoffman, J. R. (2006). Acute effects of different warm-up protocols on anaerobic performance in teenage athletes. *Ped Exe Sci*, *18*(1), 64–75. https://doi.org/10.1123/pes.18.1.64

Fletcher, I. M., & Anness, R. (2007). The acute effects of combined static and dynamic stretch protocols on fifty-meter sprint performance in track-and-field athletes. *J Strength Cond Res*, *21*(3), 784–787. https://doi.org/10.1519/r-19475.1

Gibson, A. L., Wagner, D. R. & Heyward, V. H. (2019). Advanced fitness assessment and exercise prescription. 8th ed. Human Kinetics. https://doi.org/10.5040/9781718220966

Hayes, P. R., & Walker, A. (2007). Pre-Exercise Stretching Does Not Impact Upon Running Economy. *J Strength Cond Res*, *21*(4), 1227. https:/doi.org/10.1519/R-19545.1.

Hough, P. A., Ross, E. Z., & Howtason, G. (2009). Effects of dynamic and static stretching on vertical jump performance and electromyographic activity. *J Strength Cond Res*, *23*(2), 507–512. https://doi.org/10.1519/jsc.0b013e31818cc65d

Kabešová, H. (2017). *Vliv strečinku na rozsah kloubní pohyblivosti a úroveň explozivní síly dolních končetin*. 1st ed. Univerzita J. E. Purkyně v Ústí nad Labem; 31.

Kilit, B., Arslan, E., & Soylu, Y. (2017). Effects of different stretching methods on speed and agility performance in young tennis players. *Sci Sports*, *34*(5), 313–320. https:/doi.org/10.1016/j.scispo.2018.10.016

Little, T., & Williams, A. G. (2006). Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J Strength Cond Res*, *20*(1), 203– 207. https://doi.org/10.1519/r-16944.1

McMillian, D. J., Moore, J. H., Hatler, B. S., & Taylor, D. C. (2006). Dynamic vs. static-stretching warm up: the effect on power and agility performance. *J Strength Cond Res*, *20*(3), 492–499. https:/doi.org/10.1519/18205.1

Miller, M. G., Herniman, J. J., Ricard, M. D., Cheatham, Ch. C., & Michael, T. J. (2006). The effects of a 6-week plyometric training program on agility. *J Sports Sci and Med*, *5*(3), 459–465. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3842147/pdf/jssm-05-459.pdf (accessed 2023 Nov 08)

Miri-Khorasani, M., Calleja-Gonzalez, J., & Mogharabi-Manzari, M. (2016). Acute Effect of Different Combined Stretching Methods on Acceleration and Speed in Soccer Players. *J Hum Kinetics*, *50*, 179–186. https:/doi.org/10.1515/hukin-2015-0154

Nelson, A. G., & Kokkonene J. (2021). *Stretching anatomy*. 2nd ed. Champaign, IL: Human Kinetics. https://doi.org/10.5040/9781718225633

Nelson, A. G., Driscoll, N. M., Landin, D. K., Young, M. A., & Schexnayder, I. C. (2005). Acute effects of passive muscle stretching on sprint performance. *J Sports Sci*, *23*(5), 449–454. https:/doi.org/10.1080/02640410410001730205

Nelson, R. T., & Bandy, W. D. (2005). An update flexibility. *J Strength Cond Res*, *19*, 10–16. https://doi.org/10.1519/00126548-200502000-00001

O'Sullivan, K., Murray, E., & Sainsbury, Y. D. (2009). The effect of warm-up, static stretching, and dynamic stretching on hamstring flexibility in previously injured subjects. *BMC Musculoskeletal Disorder*, *10*(37), 1–9. https://doi.org/10.1186/1471-2474-10-37

Peck, E., Chomko, G., Gaz, D. V., & Farrell, A. M. (2014). The effects of stretching on performance. *Curr Sports Med Rep*, *13*(3), 179–185. https:/doi.org/10.1249/JSR.0000000000000052

Pětivlas, T., Mrázková J. (2012) Deník trenéra basketbalu – multimediální elektronický výukový materiál. htps://is.muni.cz/do/fsps/e-learning/denik-basketbal/pages/m_beh-clunkovy.html (accessed 2023 Nov 08)

Power, K., Behm, D., Cahill, F., Carroll, M., & Young W. (2004). An acute bout of static stretching: Effects on force and jumping performance. *Med Sci Sports Exerc*, *36*(8), 1389–1396. https://doi.org/10.1249/01.mss.0000135775.51937.53

Samson, M., Button, D. C., Chaouachi, A., & Behm, D. G. (2012). Effects of dynamic and static stretching within general and activity specific warm-up protocols. *J Sports Sci Med*, *11*(2), 279–285.

Samuel, M. N., Holcomb, W. R., Guadagnoli, M. A., Rubley, M. D., & Wallmann, H. (2008). Acute effects of static stretching and ballistic stretching on measures of strength and power. *J Strength Cond Res*, *22*(5), 1422–1428. https://doi.org/10.1519/jsc.0b013e318181a314

Sayers, A. L., Farley, R. S., Fuller, D. K., Jubenville, C. B., & Caputo, J. L. (2008). The effect of static stretching on phases of sprint performance in elite soccer players. *J Strength Cond Res, 22(*5), 1416–1421. https://doi.org/10.1519/jsc.0b013e318181a450

Slomka, G., & Regelin, P. (2008). *Jak se dokonale protáhnout.* Praha: Grada Publishing.

Stewart, M., Adams, R., Alonso, A., Koesveld, B. V., & Campbell, S. (2007). Warm-up or stretch as preparation for sprint performance? *J Sci Med Sport, 10*(6), 403–410. https://doi.org/10.1016/j.jsams.2006.10.001

Taylor, K. L., Sheppard, J. M., Lee, H., & Plummer, N. (2009). Negative effect of static stretching restored when combined with a sport specific warm-up component. *J Sci Med Sport, 12*(6), 657–661. https://doi.org/10.1519/jsc.0b013e31818cc65d

Torres, E. M., Kraemer, W. J., Vingren, J. L., Volek, J. S., Hatfield, D. L., Spiering, B. A., & Maresh, C. M. (2008). Effects of stretching on upper-body muscular performance. *J Strength Cond Res*, *22*(4), 1279–1285. https:/doi.org/10.1519/JSC.0b013e31816eb501

Van Gelder, L. H., & Bartz, S. D. (2011). The effect of acute stretching on agility performance. *J Strenth Cond Res*, *25*(11), 3014–3021. https:/doi.org/10.1519/JSC.0b013e318212e42b

Yamaguchi, T. & Ishii, K. (2005). Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. *J Strength Cond Res*, *19*(3), 677–683. https://doi.org/10.1519/15044.1

Young, W., & Behm, D. (2002). Should static stretching be used during a warm-up for strength and power activities? *J Str Cond Res*, *24*(6), 33–37. https:/doi.org/10.1519/00126548-200212000-00006

Young, W. B., Clothier, P., Otago, L., Bruce, L., & Liddell, D. (2004). Acute effects of static stretching on hip flexor and quadriceps flexibility, range of motion and foot speed in kicking a football. *J Sci Med Sport, 7*(1), 23–31. https://doi.org/10.1016/s1440-2440(04)80040-9

Cite this article as: Kabešová, H., Lebrušková, L., Svoboda, D., Cihlář, D., & Bendíková E. (2025). Acute Effects of Five Different Stretching Exercises on Agility and Speed. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 21–31. https://doi.org/10.18276/cej.2025.3-02

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025: 33–45
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-03

PHYSICAL ACTIVITY, WELL-BEING REGULATION AND MOTIVATIONAL ORIENTATION IN DISADVANTAGED POPULATIONS: A PRELIMINARY CASE STUDY IN A FRENCH PRIORITY NEIGHBORHOOD

Nounagnon F. Agbangla[A, B, C, D]

Univ. Artois, Univ. Lille, Univ. Littoral Côte d'Opale, ULR 7369 – URePSSS – Unité de Recherche Pluridisciplinaire Sport Santé Société, Liévin, France
Faculté des Sports et de l'Education Physique - Chemin du marquage - 62800, Liévin, France
ORCID: 0000-0001-6734-3022 | e-mail: nounagnon.agbangla@univ-artois.fr

Isabelle Caby[D]

Univ. Artois, Univ. Lille, Univ. Littoral Côte d'Opale, ULR 7369 – URePSSS – Unité de Recherche Pluridisciplinaire Sport Santé Société, Liévin, France
Faculté des Sports et de l'Education Physique – Chemin du marquage – 62800, Liévin, France
ORCID: 0000-0002-9607-2177

Annie Carton[A, C]

Univ. Artois, Univ. Lille, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, Liévin, France
Faculté des Sports et de l'Education Physique - Chemin du marquage - 62800, Liévin, France
ORCID: 0000-0002-6457-3348

Nicolas Blondel[A, C, E]

Univ. Artois, Univ. Lille, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, Liévin, France
Faculté des Sports et de l'Education Physique - Chemin du marquage - 62800, Liévin, France
ORCID: 0000-0003-0268-5448

Williams Nuytens[A, D, E]

Univ. Artois, Univ. Lille, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, Liévin, France
Faculté des Sports et de l'Education Physique - Chemin du marquage - 62800, Liévin, France
ORCID: 0000-0002-8390-4376

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract Our study first examines the socio-demographic and psychological characteristics, and the practice of physical activities of the residents of a priority neighborhood of the local urban policy of the French northern mining basin. Second, this study seeks to identify the obstacles to exercise physical activity among the same residents, in order to propose an integrated solution for offering adapted physical activities. The field surveys collected socio-demographic data from 87 residents (M = 45.55, SD = 15.46

years; 67 women and 20 men) and measured physical activity level (Ricci and Gagnon test), well-being regulation (Diagnofeel) and motivational orientation (Motivational Orientation Questionnaire) through self-reported questionnaires. Our results allow us to distinguish two categories among these disadvantaged groups: an active and a non-active. We show that, apart from the regulation of well-being, the non-active group has the same characteristics as the active one along the other variables measured. Indeed, active people differ significantly from non-active people in their engagement in physical activity [t (85) = 4.29, p < 0.001] and pleasure [t (85) = 2.3, p = 0.024] to regulate well-being despite facing the same barriers and having similar needs as the general population. This is worth considering when developing physical activity engagement strategies and programs.

Key words: disadvantaged neighborhood, physical activity, motivational orientation, barriers

Introduction

Several arguments suggest that regular physical activity not only improves health by reducing the risk of chronic diseases, but it also reduces mortality (Cleland et al., 2014; Lee & Skerrett, 2001; Lee et al., 2012; Nyberg et al., 2025; Schwendinger et al., 2025). From a psychological perspective, studies show that engaging in physical activities increases participants' well-being (Arent et al., 2000; Thomas et al., 2021; Herbert et al., 2022; Stevens et al., 2020) at all ages of life. This engagement also simultaneously generates an increase in positive emotions (Garn & Simonton, 2022). Thus, several measures such as the National Nutrition and Health Program, the National Plan for Prevention through Physical or Sports Activities, the Sport and Health and Wellness Plan have been set up by the political authorities to promote the practice of physical activity in France (Perrin, 2019). These programs use a practical and normative approach to counteract sedentary behavior (Perrin et al., 2021; Vieille-Marchiset, 2019). However, these programs do not allow all population groups, such as those living in the priority neighborhoods of the local urban policy, to have access to regular physical exercise (Honta, 2016). However, the priority neighborhoods of the local urban policy were defined and delimited by the 2014 programming law for the city and urban cohesion to provide more resources to regions with an average annual income of less than 11 250 euros per resident. In addition to this financial criterion, the priority neighborhoods of the local urban policy are characterized by high rates of job seekers, elevated school drop-out rates and people living below the poverty threshold (Vieille-Marchiset et al., 2018). Despite these factors being considered politically at national and regional level, their action plans at times fail to reach the targeted residents in some priority neighborhoods of the local urban policy. This phenomenon can be explained by dispersed and therefore inefficient public action (Sallé et al., 2021), combined with the sedentary lifestyle residents of priority neighborhoods of the local urban policy are prone to lead (Honta, 2019).

Indeed, several studies show that such environments accumulate difficult social living conditions (Ternoy et al., 2021) for residents with little commitment to physical activity (Elhakeem et al., 2015; Gidlow et al., 2006; Degerlund Maldi et al., 2019; Sanz-Remacha et al., 2019; Williams, 2007). It now seems to be accepted that this low level of physical activity relates to unsuitable or ignored incentives, or that these incentives trigger resistance in disadvantaged populations (Vieille-Marchiset, 2019). These could be categorized in three levels of barriers (Sanz-Remacha et al., 2019). The first concerns personal barriers, including financial means, work, physical disabilities, illness, and psychological characteristics. The second type includes social barriers, e.g., problematic legacies of primary and secondary socialization (related to somatic culture, lack of social and family support). The third type refers to environmental barriers. In this regard, research have highlighted that open spaces, better street connectivity, communication between different agents (residents and community leaders); the involvement of residents in planning their physical activity; and the use of individual strategies such as adapting the activities to the needs and capacity of the participants in order to increase the level of physical activity of people living in disadvantaged areas (Cleland et al., 2014; Pearce & Maddison, 2011). These studies show that people from an unfavorable social environment are at greater risk of leading a sedentary lifestyle. According to the World Health Organization (WHO), physical inactivity remains the fourth leading risk factor for mortality worldwide (De Souto Barreto, 2013). Indeed, in adults, increased sedentary time leads not only to an increased risk of mortality triggered by obesity (De Rezende et al., 2014) but also to elevated levels of anxiety and stress (Rebar et al., 2015).

There are undoubted harmful effects caused by a sedentary lifestyle and a strong link between social conditions, levels of physical activity and general health conditions on a population level. Therefore, there can be no doubt about the vulnerable status of people living in the priority neighborhoods of the local urban policy. They are in fact the most exposed to inequality when it comes to accessing social health benefits, meaning the improvement of both the physical and psychological well-being of each person through individual recognition and social protection (Labbé et al., 2007; Paugam, 2008). And since physical activity helps to "sharpen the taste for life" and it strengthens self-esteem (Le Breton, 2003), it is also an important mean of improving the lives of disadvantaged populations. But this cannot be done unconditionally, i.e., without an adapted physical activity regime based on two principles: 1) detailed knowledge of vulnerable populations and 2) an understanding of the background of their limited involvement in physical activity. This paper follows these two principles by studying a disadvantaged neighborhood, Saint-Albert (Liévin), located in one of the most deprived areas in France. Thanks to the described scale and focus of the investigation, it is possible to examine the physical, psychological, and social characteristics of the residents. We wish to identify the obstacles that keep adult residents from engaging in physical activity in order to subsequently propose an integrated solution for offering adapted physical activity for the same group. Finally, our analyses highlight what uniquely characterizes sedentary and disadvantaged individuals: when it comes to their well-being regulation, they make significantly less use of physical activity and pleasure. In contrast, their need for practicing physical activity and the barriers that might be keeping them from doing so are the same as those observed in the general population.

Materials and Methods

Context of the study

The study was conducted in accordance with the Declaration of Helsinki and did not require ethical approval. Informed consent was obtained from all subjects involved in the study.

The study took place in the Saint-Albert neighborhood of a former mining town in the north of France where, especially until the end of the 1970s, all local life was linked to coal. Two-thirds of the area is classified as a priority urban zone (2014–2020) stretching across 120 hectares and inhabited by a population of 2760. According to the National Institute of Statistics and Economic Studies (INSEE, 2019), the poverty line is 40%, more than 60% of low incomes are declared, a quarter of households are taxed and more than 90% of households rent. There are 850 jobseekers, and 200 of them are under 26 years of age. The unemployment rate is around 35%. One of the explanations for this phenomenon is a low level of qualification, a legacy of a long history of the exclusive need for physical labor in the mining industry. The proportion of people with no qualifications exceeds 80% and only 5% of the residents have a qualification from higher (tertiary) education. Finally, available health care coverage is poor (there are no general practitioners or private paramedical professionals) and the neighborhood has less than one sports facility per 1,000 residents (i.e., 2.5 and 4 times less than at the municipal and national levels, respectively). All these indicators show the clear vulnerability of residents of the Saint-Albert neighborhood and underscores the need for investigations like the one introduced in this article.

Participants

Number of respondents

The objective of our survey was to obtain at least 30% of responses from the population of the Saint-Albert neighborhood, meaning 532 participants, and therefore we mobilized an interviewer for several weeks and opted for the door-to-door technique. However, at the end of the two visits to the neighborhood we only reached 87 respondents (10% of 865 respondents that we reached, See Figure 1).

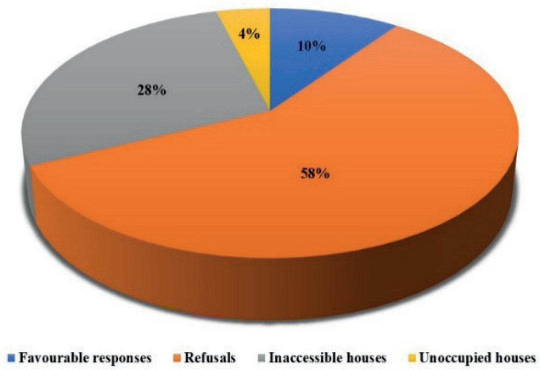


Figure 1. Distribution of residents' responses to participation in the survey or their unavailable/ absent status

Characteristics of participants

The 87 participants (20 men, 22.98%) with an average age of 45.55 ±15.46 years, ranging from 19 to 83 years. They are distributed among different socio-professional categories: senior executives (2.23% here compared with 9.5% nationwide), intermediate professionals (8% compared with 14%), employees (35.6% compared with 16%), workers (25.3% compared with 12%), pensioners (5.7% compared with 27%) and those without any professional activity (23% compared with 17%). As for the level of education, it varies between those with lower than a baccalaureate (40.23% here compared to 30% nationwide), those with a baccalaureate (26.44% compared to 17%), those with post-baccalaureate education (17.25% compared to 31%) and those with no degree from any institution of formal education (14.94% compared to 22%). The sample is composed of people displaying characteristics of their disadvantaged social backgrounds.

Measured parameters

Global questionnaire

The global questionnaire integrates several categories of questions: socio-demographic questions, questions related to past physical activity practice and questions related to needs regarding physical activity practice and also barriers that might keep respondents from engaging. The questionnaire collected information on age, gender, occupation, degree obtained, past participation in the respective physical activity, screen time spent watching sports programs, needs and barriers.

The Ricci & Gagnon questionnaire (measuring physical activity levels)

The residents' physical activity levels were measured using the Ricci & Gagnon questionnaire (n. d) modified by Laureyns &Séné. This tool, which has been validated for both sedentary and active people, consists of 9 questions. On the basis of the response scores (ranging from 1 to 5), an overall score is calculated. A final score below 18 corresponds to a non-active status, a score between 18 and 35 corresponds to an active status and a score above 35 means that the participant is very active physically.

Measuring well-being regulation (Diagnofeel)

The regulation of well-being was measured by the Diagnofeel questionnaire. It assesses the 5 regulation elements of well-being (IRFO, n. d), i.e., social relations, pleasure, physical activity, problem solving and psychological distancing. The Diagnofeel consists of 20 items to which participants respond by using a Likert scale ranging from 1 (strongly disagree) to 10 (strongly agree). Scores are then summarized by regulation elements, adding the scores of each associated item.

Regulatory Focus Questionnaire-Proverbs Form (RFQ-PF)

Self-reported and composed of two subscales related to promotion and prevention (Faur et al., 2017), the motivational orientation questionnaire contains proverbs (RFQ-PF). A promotion orientation means that people are sensitive to gains and non-gains, setting action-oriented goals to achieve the desired results. A prevention orientation, on the other hand, means that people are sensitive to losses and non-losses, show less risk-tolerance and are motivated by psychological safety and stability. The questionnaire consists of 18 items (8 items relate to promotion and 10 to prevention orientation). Participants can respond on a Likert scale from 1 (not at all) to 7 (perfectly). The determination of the promotion and prevention scores is based on mathematical equations (See the equations 1 and 2). Scores for items are summarized on each sub-scale, then divided by the number of the items on the respective subscale. Whichever sub-score is higher, determines the person's orientation.

(1) Promotion = (item 1 + item 5 + item 7 + item 10 + item 12 + item 14 + item 15 + item 18) / 8

(2) Prevention = (item 2 + item 3 + item 4 + item 6 + item 8 + item 9 + item 11 + item 13 + item 16 + item 17) / 10

Procedure: field study and analytic strategy

A field survey was carried out in the Saint-Albert neighborhood from 18 June to 2 August 2019 (period before the Covid-19 pandemic). It involved going door-to-door along about 60 streets to seek out the residents of nearly 865 homes. The administration of the questionnaires invariably followed this pattern: the participants first had to give their consent by signing the informed consent form and then agree to fill out the questionnaires (1) global questionnaire; 2) Ricci & Gagnon; 3) Diagnofeel; 4) RFQ-PF). A descriptive analysis was carried out based on the data collected by the global questionnaire. Two groups were formed a posteriori based on the participants' scores on the Ricci & Gagnon questionnaire (active and non-active). Following the identification of the two groups, Student or Welch tests were used after checking the normality of the data and the homogeneity of the variances to compare the two groups using the JASP version 16.1 software. Specifically, a second analysis was carried out to compare members of the active group based on their practice of physical activities being supervised or non-supervised. The significance level was set at $p \leq 0.05$.

Results

Participants' level of physical activity in the past and at the time of the survey

46 of our 87 participants had not practiced any physical activity in the past. Of these, 26 remained inactive at the time we conducted our survey. On the other hand, 41 participants had practiced in the past, out of which group 17 became inactive. The Ricci & Gagnon results show an overall participants' score of 19.55 ±7.89. This result might suggest that all participants are active at the time of the survey, yet examination of the individual scores reveals Ricci & Gagnon scores below 18. Based on a Ricci & Gagnon survey score, we distinguished 2 groups: an active group with a score of 26.07 ±5.28 and a non-active group with a score of 12.88 ±2.99. Furthermore, among the working people, 13 (29.55%) practice supervised activities (twice a week on average) and 31 (70.45%) practice unsupervised activities. Active people with club memberships play football, participate in weight training, fitness, Zumba, toning, badminton, cardio and dance. On the other hand, people who practice outside of clubs do bowling, walking, swimming, weight training and cycling. The characteristics of the active and non-active groups are shown in Table 1.

Table 1. The characteristics of the active and non-active sub-samples.

	Active (N = 44)	Inactive (N = 43)
Age (M ±SD)	45.41 ±15.57 years	45.69 ±15.53 years
Age range	19–81 years	23–83 years
Gender (Women/Men)	34/10	33/10
Unemployed	8 (for an average of 3.50 years)	6 (for an average of 2.31 years)
Time spent watching sports on TV	2.67 ±2.19 hours	2.45 ±2.13 hours
Participants with health problems	12	14

Regulation of participants' well-being

The comparison of active and non-active people in terms of well-being regulation (see Figure 2a) shows that, regardless of the group membership, social relations are the primary regulatory element. This is followed by psychological distancing, pleasure, problem solving and physical activity in last place. The results also indicate that the two groups differ significantly in their use of physical activity [$t(84.39) = 4.3$, $p < 0.001$] and pleasure [$t(85) = 2.3$, $p = 0.024$] to regulate their well-being. Indeed, active people make significantly more use of physical activity and pleasure to regulate their well-being than non-active people, who rather tend to use social relations and psychological distancing. A second level of analysis focused on the influence of the supervised or unsupervised nature of physical activities. People with club memberships use physical activity as their primary means of well-being regulation. This is followed by psychological distancing, pleasure, social relations and finally, problem solving. In contrast, non-club practitioners use social relations as the first regulatory element before enjoyment, decision making, problem solving and finally physical activity (see Figure 2b). Finally, the two groups utilize social relations differently: active people practicing outside of clubs make more use of social relations than their counterparts practicing in clubs, but this difference is not significant (p = 0.061).

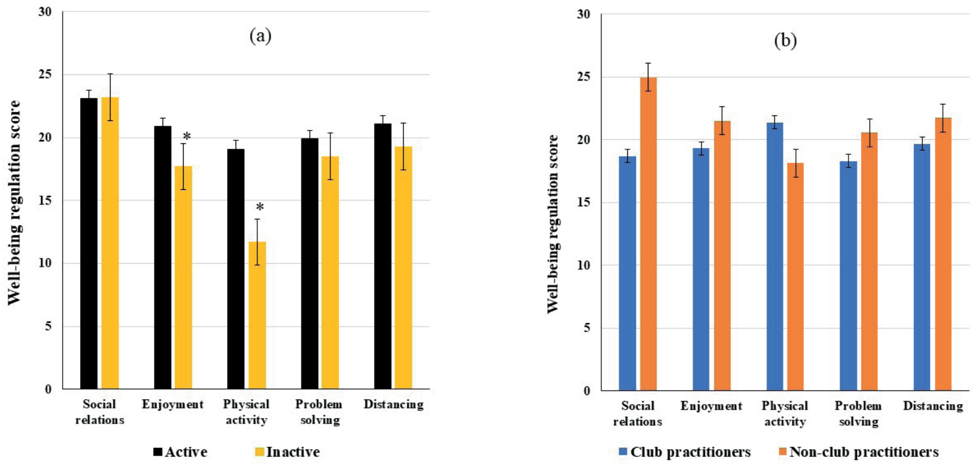


Figure 2. Regulation of well-being according to the level of physical activity and the nature of physical practice. (**a**) Comparison between active vs. inactive people; (**b**) Comparison between active club practitioners and active non-club practitioners; * Significant difference

Motivational orientation

The motivational orientation scores for the active and inactive groups are –0.04 ±0.71 and –0.12 ±0.72, respectively. The comparison via t-test shows no significant difference (p = 0.6). Considering these results, it appears that participants would look at both losses and gains before engaging in physical activity. Finally, with specific regard to active people, the scores vary for club practitioners from –0.31 ±0.43 and 0.08 ±0.7 for non-club practitioners.

Barriers and needs

Active and inactive people mention the same barriers overall (apart from the influence of the weather cited by active people and the lack of infrastructure cited by inactive people, see Figure 3). In detail, the barriers mentioned by the active group include lack of time, workload, health, financial means, lack of motivation, the weather, and no specific influence (nothing). The inactive share this last point as the influence of health, lack of time, work weight, insufficient motivation, insufficient financial means, lack of infrastructure, and no specific influence (nothing).

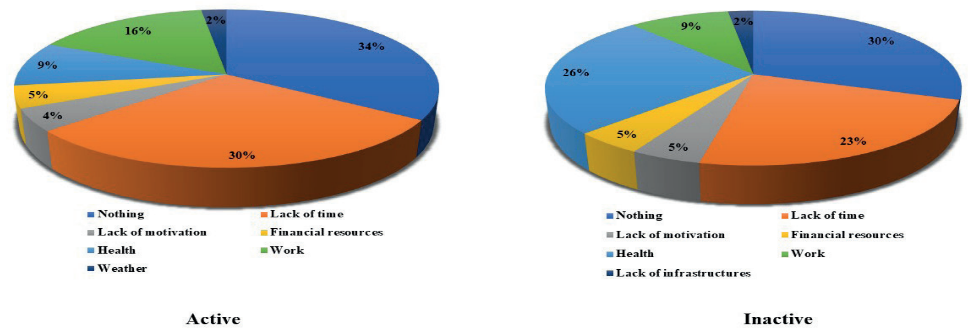


Figure 3. Barriers to practicing physical activities reported by participants

Concerning the needs (meaning the requirements to be able to practice physical activities), the results show that some active people do not have any. However, other active people highlighted the need for infrastructure, sports associations, fitness classes, the means of transport to the places of practice. Concerning the non-active, some express no needs or demands. However, other non-active people express the need for better infrastructure, the establishment of fitness classes, financial aid, and the creation of sports associations (See Figure 4).

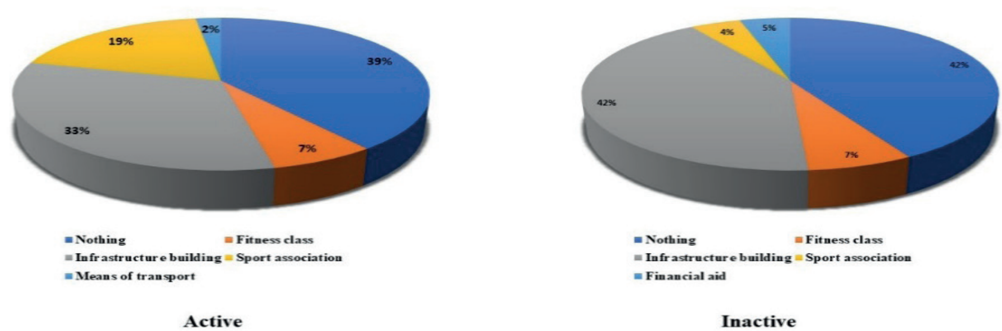


Figure 4. Requirements reported by participants as a function of their level of physical activity

Finally, we analyzed the results with a focus on the group of active people. The two sub-groups (people practicing in a club and people practicing without a club membership) reported 1) different barriers (circumstances that keep them from practicing physical activities): “no specific barrier/ reason” (5 vs. 10), “work” (3 vs. 4), “time constraints” (2 vs. 11), “health problems” (1 vs. 3), “financial means” (1 vs. 1); 2) different needs/ demands for engaging in physical activities: “none” (6 vs. 12), “lack of infrastructure” (5 vs. 9), “lack of sports associations” (1 vs. 7), “fitness classes” (1 vs. 2).

Discussion

Our study aimed to identify the characteristics of the residents of a disadvantaged neighborhood, the obstacles to their involvement in physical activity, and their specific needs. Our multidisciplinary team (psychologists, physiologists, and a sociologist) used a door-to-door survey approach for data gathering. We believe the above was needed to successfully approach the target group, to implement various measurement tools to circumvent two obstacles to social change: public action that is too sectorized and insufficiently coordinated (Sallé, 2021), and the inactive lifestyle characteristic of residents of priority neighborhoods of the local urban policy (Honta, 2019), which is exemplary in this respect (Saint-Albert).

First of all, we regret the low percentage of positive responses (10%) obtained during our surveys. This result could be explained by the remoteness, refusal or ignorance of the WHO recommendations concerning the practice of physical activity by the residents of the Saint-Albert neighborhood. Indeed, living under disadvantaged conditions, residents are less involved in physical activity, which is alarming, as inactivity is strongly linked with precariousness (Elhakeem et al., 2015; Gidlow et al., 2006; Degerlund Maldi et al., 2019; Sanz-Remacha et al., 2019; Williams, 2007). The lack of interest on the part of residents remains a concern. These findings could be a base for proposing strategies to elevate engagement in physical activities in the underprivileged areas; as being physically active is not only an important determinant of health (Wilkinson et al., 2003) but also plays a major role in reducing health inequalities (Vuillemin, 2016).

The residents who agreed to participate in our study have, overall, a level of physical activity at the lower end of the active population. Their levels of practice fail to meet the WHO recommendations, meaning they don't get to enjoy all benefits of physical activities. However, a more detailed analysis shows that half of the participants are inactive. Moreover, of the active participants, only 1/3 were involved in supervised activities. This low level of practice among the residents of the Saint-Albert neighborhood confirms the results of previous studies which were carried out in disadvantaged neighborhoods, highlighting the low level of physical activity practice (Elhakeem et al., 2015; Gidlow et al., 2006; Degerlund Maldi et al., 2019). Apart from the social environment, which could explain the low level of residents' physical activity, the barriers mentioned by the participants could shed further light on the phenomenon. In addition to the influence of the weather and the lack of infrastructure mentioned by the active and inactive population respectively, there are other barriers that seem to be common for both the active and inactive population. These include health problems, work as a discriminating factor, various shortages (of time, motivation, economic capital) and the constraints associated with childcare. These barriers are consistent with factors negatively associated with physical activity practice identified in a seminal report (INSERM, 2014) and concur with findings from work examining disadvantaged (Sanz-Remacha et al., 2019) and non-disadvantaged populations (André & Agbangla, 2020). Thus, strategies to counteract these barriers are essential to increase the level of practice of vulnerable residents. A circumvention strategy can be used to reach people with health problems specifically, for example by prescribing therapeutic physical activity for them. However, such a strategy must be known and accepted by the users. And it is important to make sure this partially medicalized activity will not cause iatrogenic effects that might further distance disadvantaged populations from utilizing the provided programs. The sport and health facilities, installed in the regions since the beginning of the 2020s, may be an effective way to combat the sedentary lifestyle. We have also identified needs associated with infrastructure and availability of physical practice. This need reflects a lack and, perhaps, an inadequacy of planning policies that successfully facilitate access to priority neighborhoods of the local urban policy. This would potentially be an effective step to combat constraints associated with lack of time, especially if these facilities host light and short forms of physical practice. In sum, the promotion of physical activity in an area where people are prone to lead sedentary lives, could be achieved by using two strategies: education, and modification of the physical and social environments. The educational strategy would aim to change beliefs, knowledge, behaviours, and individual resources to ultimately develop. As for the strategy of modifying the physical and social environment, its aim would be to develop and organize physical activities for the target population.

As for the motivational orientations, several uncertainties persist because of an absolute score very close to 0. Thus, the declared commitment would not be significantly linked to the fact of organizing oneself to avoid losses or to seek the gains of a practice. Overall, our results show that participants, regardless of whether they are active or inactive, fall into both the promotion and prevention categories. As for the regulation of well-being, our results showed that, overall, active and inactive participants regulate their well-being by using social relationships in the first place. This result confirms previous results, highlighting how social support makes it possible, under unstable circumstances, to recover a level of well-being (Binder & Coad, 2011; Sarason et al., 2021; Thoits, 2011; Turner, 1981). Furthermore, participants seemed to signify the importance of psychological distancing, enjoyment and problem solving. This use of distancing and problem solving suggests ways of minimizing the intensity of stress, and thus the harmful effects of their experiences that affect their well-being. In contrast, the use of pleasure allows participants to connect to positive emotions. Finally, the participants mention the use of physical activities in the last place. This low use of well-being regulation could be explained by the fact that the residents of this underprivileged neighborhood have not developed physical literacy, i.e., knowledge that allows them to utilize publicly available sports opportunities in order to be able to benefit from them in terms of well-being regulation. Thus, when faced with situations that negatively impact their well-being, they mobilize this resource less. However, studies have showed a relationship between physical activity and psychological well-being (Elvsky et al., 2005; Kahn et al., 2002). Nevertheless, when we compare active club and active non-club practitioners, we find that active club practitioners use physical activity first, while active non-club practitioners use social relationships.

Our study has several limitations, some of which have already been noted. One of them is the size of the sample, which prevents any generalization or systematization. Moreover, the gender imbalance in our sample limited our ability to examine the evolution of the studied characteristics across genders. Future research should include a larger sample with similar profiles and compare it to a group of less disadvantaged individuals. Research techniques, other than door-to-door, should be used to widen the scope: the ethnographic approach offers this advantage, but it remains costly and extremely time-consuming (Demazière & Nuytens, 2018; Nuytens, 2011; Nuytens, 2014). A final well-identified limitation concerns the measurement of physical activity. Carried out with the help of self-reported questionnaires, this measurement involves a possible desirability bias that should be controlled by using, for example, more objective tools with actimeters.

Conclusions

Our study confirms that many residents of culturally and socially disadvantaged area stay away from physical activities. Literature and our surveys suggest that these people are caught in a circle from which it is difficult to escape. Their primary and secondary socialization often causes several sedentary effects which are further worsened by fragmented and more or less ineffective local and national public policies. Breaking out of such a set of circumstances implies building and exploring strategies for social change, behavioral change, and engagement in physical activities. For a problem of this complexity, only the construction of an interventional and conditional physical activities program seems to provide a successful solution. For example, the effectiveness of a multicomponent strategy could be tested, by combining information actions such as neighborhood campaigns, support of the individual's entourage, and setting up of physical activity slots in the neighborhood (Kahn et al., 2002).

Consequently, this exploratory study should pave the way for further research, particularly aimed at enhancing the existing body of knowledge through future investigations conducted on larger and more representative samples."

Funding: This research was funded by « Centre National pour le Développement du Sport (CNDS, Ministère des sports 2019-2020) - APS et sédentarité dans un QPV : études préliminaires à un protocole d'intervention dans le cadre d'un Ami Liv Lab Sport 2018 » and « This article has been supported by the European center for humanities and social sciences (MESHS-Lille, France) »".

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

References

André, N., & Agbangla, N. F. (2020). Are Barriers the Same Whether I Want to Start or Maintain Exercise? A Narrative Review on Healthy Older Adults. *International Journal of Environmental Research Public Health*, *17*, 6247. https://doi.org/10.3390/ijerph1717624747

Arent, S.M., Landers, D.M., Etnier, J. (2000). The effects of exercise on mood in older adults: A Meta-Analytic Review. *Journal of Aging and Physical Activity*, *8*(4), 407–430. https://doi.org/10.1123/japa.8.4.407

Biddle, S. J. H., Fox, K., & Boutcher, S. (2003). Physical activity and psychological well-being. Routledge 1st Edition London, pp. 220 https://doi.org/10.4324/9780203468326

Binder, M., & Coad, A. (2011). From Average Joe's happiness to Miserable Jane and Cheerful John: using quantile regressions to analyze the full subjective well-being distribution. *Journal of Economic Behavior and Organization*, *79*(3), 275e290. http://dx.doi.org/10. 1016/j.jebo.2011.02.0 05

Cleland, C. L., Hunter, R. F., Tully, M. A., Scott, D., Kee, F., Donnelly, M., Prior, L., & Cupples, M. E. (2014). Identifying solutions to increase participation in physical activity interventions within a socio-economically disadvantaged community: a qualitative study. *International Journal of Behavioral Nutrition and Physical Activity*, *11*, 68. https://doi.org/10.1186/1479-5868-11-68

Degerlund Maldi, K., San Sebastian, M., Gustafsson, P. E., & Jonsson, F. (2019). Widespread and widely widening? Examining absolute socioeconomic health inequalities in northern Sweden across twelve health indicators. *International Journal for Equity in Health*, *18*, 197. https://doi.org/10.1186/s12939-019-1100-5

Demazière, D., & Nuytens W. (2018). Que faire avec des matériaux incertains ? Le cas des violences dans le football amateur, *Sciences et Techniques des Activités Physiques et Sportives*, *122*, 31–44. https://doi.org/10.3917/sta.122.0031

De Rezende, L. F., Rey-López, J. P., Matsudo, V. K., & do Carmo Luiz, O. (2014). Sedentary behavior and health outcomes among older adults: a systematic review. *BMC Public Health*, *14*:333. https://doi.org/10.1186/1471-2458-14-333

De Souto Barreto, P. (2013). Pourquoi ne parvenons-nous pas à promouvoir l'activité physique au niveau mondial ?, *Bulletin de l'Organisation mondiale de la Santé*, *91*, 390–390.

Elhakeem, A., Cooper, R., Bann, D., & Hardy, R. (2015). Childhood socioeconomic position and adult leisure-time physical activity: a systematic review. *International Journal of Behavioral Nutrition and Physical*, *12*, 92. https://doi.org/10.1186/s12966-015-0250-0

Elavsky, S., McAuley, E., Motl, R. W., Konopack J. F., Marquez D. X., Hu, L., Jerome, G. J., & Diener E. (2005). Physical activity enhances long-term quality of life in older adults: efficacy, esteem, and affective influences. *Annals of Behavioral Medicine*, *2*, 138–45. https://doi.org/10.1207/s15324796abm3002_6

Faur, C., Martin, J.-C., & Clavel, C. (2017). Measuring chronic regulatory focus with proverbs: The developmental and psychometric properties of a French scale. *Personality and Individual Differences*, *107*, 137–145. https://doi.org/10.1016/j.paid.2016.11.037

Garn, A. C., Simonton, K. L. (2022). Motivation beliefs, emotions, leisure time physical activity, and sedentary behavior in university students: A full longitudinal model of mediation. *Psychology of Sport and Exercise*, *58*, 10. https://doi.org/10.1016/j.psychsport.2021.102077

Gidlow, C., Johnston, L. H., Crone, D., Ellis, N., & James, D. (2016). A systematic review of the relationship between socio-economic position and physical activity. *Health Education Journal*, *65*, 338e367. https://doi.org/10.1177/0017896906069378

Honta, M. (2006). The state and management of partnership arrangements in France. An analysis of the implementation of the sport, health and well-being plan. *International Journal of Sport Policy and Politics* 2016, *8*, 577–591. https://doi.org/10.1080/19406940.2016.1189954

Honta M. (2019). La mise en oeuvre du Plan Sport, Santé, Bien-Etre en région. Un processus d’ajustements continus. *Santé Publique*, *4*, 475–484.

Herbert C. (2022). Enhancing Mental Health, Well-Being and Active Lifestyles of University Students by Means of Physical Activity and Exercise Research Programs. *Frontiers in public health*, *10*, 849093. https://doi.org/10.3389/fpubh.2022.849093

INSEE, « Dossier complet » commune de Liévin, publié le 19/09/2019

INSERM (2014). Inégalités sociales de santé en lien avec l’alimentation et l’activité physique, Paris, 2014.

IRFO. Diagnofeel. https://irfo.fr/diagnofeel/ (accessed on 20/10/2022).

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., Stone, E. J., Rajab, M. W., & Corso, P. (2002). The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine*, *22*, 73–107. https://doi.org/10.1016/s0749-3797(02)00434-8

Labbé, E., Moulin, J.-J., Guéguen, R., Sass, C., Chatain, C., & Gerbaud, L. (2007). Un indicateur de mesure de la précarité et de la santé sociale : le score Epices. *La Revue de l’Ires*, *53*, 3–49.

Le Breton, D. (2003). Activités physiques et sportives et intégration : aspects anthropologiques. *Empan*, *51*, 58–64. https://doi.org/10.3917/empa.051.0058

Lee I. M., & Skerrett P. J. (2001). Physical activity and all-cause mortality: what is the dose-response relation? *Medicine and Science in Sports and Exercise*, *33*, 459–471. https://doi.org/10.1097/00005768-200106001-00016

Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., Katzmarzyk, P. T., & Lancet Physical Activity Series Working Group (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*, *380*(9838), 219–229. https://doi.org/10.1016/S0140-6736(12)61031-9

Nuytens, W. (2014). Facteur de troubles ? La vigilance au cours d’une enquête de longue durée. *Recherches Qualitatives*, *33*(1), 64–85. https://doi.org/10.7202/1084392ar

Nuytens, W. (2011). L’épreuve du terrain. Violences des tribunes, violences des stades. Rennes, Presses Universitaires de Rennes, coll. Des sociétés.

Nyberg, S. T., Frank, P., Pentti, J., Alfredsson, L., Ervasti, J., Goldberg, M., Knutsson, A., Koskinen, A., Lallukka, T., Nordin, M., Rahkonen, O., Strandberg, T., Suominen, S., Väänänen, A., Vahtera, J., Virtanen, M., Westerlund, H., Zins, M., Stenholm, S., Sabia, S., … Kivimäki, M. (2025). Health benefits of leisure-time physical activity by socioeconomic status, lifestyle risk, and mental health: a multicohort study. *The Lancet. Public health*, *10*(2), e124–e135. https://doi.org/10.1016/S2468-2667(24)00300-1

Paugam S., Le lien social, Paris, PUF, 2008.

Pearce, J. R., & Maddison, R. (2011). Do enhancements to the urban built environment improve physical activity levels among socially disadvantaged populations? *International Journal for Equity in Health*, *10:*28. https://doi.org/10.1186/1475-9276-10-28

Perrin, C. (2019). Logiques et modalités d’intervention en activité physique auprès des malades chroniques : approches sociologiques. In Expertise collective Inserm : Activité Physique, prévention et traitement des maladies chroniques, Montrouge : EDP Sciences, pp. 49–100.

Perrin, C., Dumas, A., & Vieille Marchiset, G. (2021). L’activité physique comme objet de santé publique : fabrique, diffusion et réception des nouvelles normes de santé active, *SociologieS* [En ligne], Dossiers, mis en ligne le 02 février 2021. https://doi.org/10.4000/sociologies.15612

Rebar, A. L., Stanton, R., Geard, D., Short, C., Ducan, J., & Vandelanotte, C. (2015). A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review*, *9*, 336–378. https://doi.org/10.1080/17437199.2015.1022901

Ricci, X., & Gagnon, L. (n.d). Test de sédentarité et activité physique, d'après Ricci et Gagnon, Université de Montréal, (modifié) par Laureyns et Séné.

Sallé, L., Honta, M., & Haschar-Noé, N. (2021). Les injonctions contradictoires à l'intersectorialité dans l'action publique sanitaire. L'exemple du Programme National Nutrition Santé. *Sciences Sociales et Santé*, *3*, 79–105. https://doi.org/10.1684/sss.2021.0206

Sanz-Remacha, M., García-González, L., Sevil Serrano, J., Generelo Lanaspa, E., & Aibar Solana, A. (2019). Barriers to Physical Activity in Disadvantaged Population: A Qualitative Comparison between Roma and Non Roma Women. *Research Quarterly for Exercise and Sport*, *90*, 567–577. https://doi.org/10.1080/02701367.2019.1635245

Sarason, B. R., Sarason, I. G., & Gurung, R. A. R. (2021). Close personal relationships and health outcomes: A key to the role of social support. In B. Sarason & S. Duck (Eds.), Personal relationships: Implications for clinical and community psychology Chichester, UK: Wiley? pp. 15–41.

Schwendinger, F., Infanger, D., Lichtenstein, E., Hinrichs, T., Knaier, R., Rowlands, A. V., & Schmidt-Trucksäss, A. (2025). Intensity or volume: the role of physical activity in longevity. *European journal of preventive cardiology*, *32*(1), 10–19. https://doi.org/10.1093/eurjpc/zwae295

Stevens, M., Rees, T., Coffee, P., Steffens, N. K., Haslam, S. A., & Polman, R. (2020). Leading us to be active: A two-wave test of relationships between identity leadership, group identification, and attendance. *Sport, Exercise, and Performance Psychology, 9*(1), 128–142. https://doi.org/10.1037/spy0000164

Ternoy, M., Nuytens, W., & Amoura, C. (2021). Tout n'est pas perdu. La possibilité d'autres sociaux du corps parmi les populations socialement vulnérables, *Recherches & éducations*, [En ligne], *22*, 2021. https://doi.org/10.4000/rechercheseducations.11113

Thoits, P.A. (2011). Mechanisms linking social ties and support to physical and mental health. *Journal of Health and Social Behavior*, *52*, 145–161. http://dx.doi.org/10.1177/0022146510395592

Thomas, J., Bowes, N., Meyers, R., Thirlaway, K. (2021). Mental well-being and physical activity of young people experiencing homelessness before and during COVID-19 lockdown: A longitudinal study. *Mental Health and Physical Activity*, 100407. doi: 10.1016/j.mhpa.2021.100407

Turner, R. J. (1981). Social support as a contingency in psychological well-being. *Journal of Health and Social Behavior*, 357–367

Vieille-Marchiset, G., Knobé, S., Edzard, E., Piombini, A., & Enaux, C. (2018). Usages du vélo et rapports aux espaces publics des enfants : permanence de la division par sexe dans un dispositif d'apprentissage dans un quartier populaire à Strasbourg. *Enfances, Familles, Générations*, *30*. https://doi.org/10.7202/1058684ar

Vieille-Marchiset, G. La conversion des corps. Bouger pour être sain, Paris, L' Harmattan, coll. « Logiques sociales », 2019, 156 p.

Vuillemin, A. (2016). Inégalités sociales et activité physique. Debout L'Info (Observatoire National de l'Activité Physique et de la Sédentarité), *2*, 1–5.

Wilkinson, R., Marmot, M., & World Health Organization. (2003). Regional Office for Europe. Social determinants of health: the solid facts, 2nd ed (en). World Health Organization. Regional Office for Europe. https://apps.who.int/iris/handle/10665/326568

Williams, C. (2007). The built environment and physical activity: what is the relationship? New Jersey: Robert Wood Johnson Foundation.

Cite this article as: Agbangla, N. F., Caby, I., Carton, A., Blondel, N., & Nuytens, W. (2025). Physical Activity, Well-being Regulation and Motivational Orientation in Disadvantaged Populations: A Preliminary Case study in a French Priority Neighborhood. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 33–45. https://doi.org/10.18276/cej.2025.3-03

ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-04

CONTROL OF PHYSICAL FITNESS OF 5TH–9TH GRADES SCHOOL STUDENTS

Ihor Bakiko[A, B, C, D, E]

Lutsk National Technical University, Lutsk, Ukraine
ORCID: 0000-0002-8835-8781 | e-mail: bakiko_ihor@ukr.net

Volodymyr Kovalchuk[B, C]

Lutsk National Technical University, Lutsk, Ukraine
ORCID: 0000-0001-5888-7458

Sergiy Savchuk[B]

Lutsk National Technical University, Lutsk, Ukraine
ORCID: 0000-0001-7615-5461

Volodymyr Faidevych[A]

Lutsk National Technical University, Lutsk, Ukraine
ORCID: 0000-0001-8432-3074

Anatoliy Volchinskiy[D]

Lesya Ukrainka Volyn National University, Lutsk, Ukraine
ORCID: 0000-0002-5204-6823

Olexander Valkevich[A]

Lesya Ukrainka Volyn National University, Lutsk, Ukraine
ORCID: 0000-0003-1229-5056

Olexander Krypliuk[A]

Academy of Recreational Technologies and Law, Lutsk, Ukraine
ORCID: 0000-0002-4190-1628

[A]Study Design; [B]Data Collection; [C]Statistical Analysis; [D]Manuscript Preparation; [E]Funds Collection

Abstract ***Background and Study Aim*:** Recently, in Ukraine, along with the deterioration of health, there has been a decrease in the level of physical fitness of schoolchildren. Management of the process of physical education of schoolchildren is based on a system of control over the level of their physical fitness. Testing of physical fitness is an element of stage control both in the system of sports training and in the practice of physical education. In recent years, scientific literature and reports by researchers and practitioners have actively discussed the appropriateness of using movement tests to assess schoolchildren's physical fitness during physical education. These discussions focus on the informational value of such tests in relation to physical health indicators, as well as the standards for interpreting the test results.

Purpose: to determine the dynamics of physical fitness of students of grades 5–9 during their studies at school.
Material & methods: 300 students of grades 5–9 of Lutsk comprehensive school No. 17 took part in the study. Nine control exercises were used to determine the level of physical fitness. The research was at the school stadium and in the school's sports hall. We obtained parental consent for their children's participation in the experiment.
***Results*:** Studies have shown that children have an average level of physical fitness. A low level of physical fitness was demonstrated during the endurance test. Below average physical fitness was found during the speed test and the long jump test while the sit up test demonstrated above average results.
Conclusion. The relevance of our research lies in the fact that it has revealed which physical qualities are underdeveloped in schoolchildren. This will help the physical education teacher to introduce appropriate adjustments to the pedagogical process to enhance the physical fitness of students.

Key words: physical education, students, speed, endurance, strength.

Introduction

In recent years, the special literature discusses the feasibility of using motor tests to monitor physical fitness (Aperman-Itzhak et al., 2018; Grasten, 2017). The basis of the national system of physical education is a set of indicators. It includes: the number of weekly physical activity, physical development, functional state of body systems, physical performance and motor skills (Baranowski, 2017; WHO, 2019).

This set of indicators can sufficiently characterize person's physical condition (Greco et al., 2019; WHO, 2019). It makes it possible to determine the viability of the human body and improve it through exercise (Hynynen et al., 2016; WHO, 2019). This is particularly relevant for assessing physical fitness (Andrieieva et al., 2020; Jongenelis et al., 2018).

By choosing tests, you can determine the level of functioning of individual body systems (Drljačićet al., 2012; Jongenelis et al., 2018; Yelizarova et al., 2020). Performing physical exercises in the classroom can influence the level of their functioning, and thus improving health (Minatto et al., 2019; Yuksel, 2019; Andrieieva et al., 2019).

Basic physical abilities improve as the body grows and develops. Each of them has sensitive periods (Pbert et al., 2016; Panhelova & Tsapuk, 2018; Van de Kop et al., 2019). The processes of growth and development in adolescents are characterized by irregularity and fluctuation. (Drozdovska et al., 2020; Fedorov & Sharmanova, 2004). This is an adaptation, the development of evolution (Tian et al., 2017; Krutsevich, 2003; Petrachkov et al., 2022). The development of the child's body directly depends on the activity of skeletal muscles. Also sufficient musculoskeletal activity or hypodynamics and hypokinesia, which inhibits this process (Hakman et al., 2020; To et al., 2019; Erhan & Tamer, 2017). A certain amount of muscular load is necessary for a teenager not only for physical but also for intellectual development (Kuzmenko, 2013; Physical education curriculum for secondary schools. Grades 5 – 9. MONU). During the study, test tasks that were used have a high degree of reliability and informativeness (Mameshina et al., 2015; Yarmak et al., 2018).

The purpose of the study was to examine the dynamics of physical fitness among students in grades 5 to 9 during their school years.

Material and Methods

Participants: 300 schoolchildren (150 boys and 150 girls) of the 5th–9th grades of the Lutsk General Education School of the I–III degrees No. 17 took part in the study. The study was conducted at the school stadium and in the school's sports hall.

The scientific research procedure was conducted in accordance with the ethical standards of the responsible human rights committee with the approval of the Department of Education and Science of the executive body of the Lutsk City Council and the written consent of the director of school and the parents of the respondents, which is confirmed by relevant documents.

Procedure: The research was conducted during the 2023–2024 academic year and consisted of three stages. At the first stage of the research, we analyzed the scientific and methodological and special literature. For control tests, a test battery was used to determine the level of development of various physical qualities, namely:

- 30 m and 60 m sprint;
- Steady running (1000 m and 1500 m);
- Pull-ups on a horizontal bar (boys) and push-ups from a lying position (girls);
- Handgrip dynamometry;
- Sit-ups in 1 minute;
- Standing long jump;
- 4 × 9 m shuttle run;
- Sit and reach test (forward bend from a sitting position);
- Flamingo balance test.

All of students systematically took part in physical education classes twice a week. Control tests from the school physical education program for grades 5–9 were used, with the permission of the school doctor.

Reception of control exercises was carried out twice. Primary testing at the beginning of the school year – to determine the initial level of physical fitness of students in grades 5–9. Final testing – at the end of the school year to determine changes in the physical fitness of children during their studies.

The Eurofit test battery was used for the study (Drljačić et al., 2012; Fedorov et al., 2004; Yelizarova et al., 2020). At the third stage, based on the use of the method of mathematical and statistical processing of the obtained data, we found out the level of development of the basic motor qualities of students of grades 5–9 and their dynamics during the academic year.

Statistical analysis: informed consent for participation in this experiment was obtained from all participants. Statistical processing of the study materials was conducted using Microsoft Excel 2010. The arithmetic mean and the bias of the arithmetic mean were calculated. The credibility of differences between sample rates was tested using the Student's t-test and considered statistically significant at $p > 0,05$.

Results

To determine the physical fitness of adolescents, we used motor tests aimed at assessing each physical quality (Table 1, Table 2). In physical education and wellness training, it is important to cultivate the ability to exhibit speed in holistic motor activity. Speed is characterized by the ability to perform the maximum number of movements over a period of time. This quality is extremely important in cyclic motor actions. Therefore, the speed study was based on the analysis of the dynamics of running adolescents 30 m, 60 m.

Table 1. Indicators of physical fitness of 5-th – 9-th grade boys (n = 150)

n	Test	Before the experiment		After the experiment		Δx	t	p
		X	s	X	s			
				5th grade				
1	30 m sprint (s)	6.70	1.36	6.30	0.3	0.1	0,04	< 0,05
2	Steady running 500 (m)	690	143	750	0.75	0.5	0,2	< 0,01
3	Pull-ups on a horizontal bar	7.52	1.18	8.63	0.73	0.01	0,69	< 0,05
4	Handgrip dynamometry	13,6	0,96	13,8	1,2	0,2	1,35	< 0,05
5	Sit-ups in 1 minute	24.80	1.03	26,34	0,8	0,1	0.65	< 0,05
6	Standing long jump(c)	134.5	2.32	141.20	2.09	1.1	2,50	< 0,05
7	4 × 9 m shuttle run(s)	12.24	6.0	12.0	0.18	0.11	0,03	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	3.4	0.52	3.6	0.73	0.1	0,9	< 0,05
9	Flamingo balance test	16	2.3	14	1.01	0.02	10,28	< 0,01
				6th grade				
1	60 m sprint (s)	6.29	0.15	6.0	0.2	0.2	0,04	< 0,05
2	Steady running 600 (m)	855	145	1000	0.34	0.3	0,1	< 0,01
3	Pull-ups on a horizontal bar	12.70	0.3	13.1	0.1	0.1	0.23	< 0,05
4	Handgrip dynamometry	4.03	0.4	4.7	0.2	0.4	1.19	< 0,05
5	Sit-ups in 1 minute	27.10	0.31	28.09	0.3	0.3	1,01	< 0,05
6	Standing long jump(c)	148.67	1.13	150.0	1.0	1.0	2.13	< 0,05
7	4 × 9 m shuttle run(s)	11.58	0.7	11.3	0.24	0.1	0,02	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	3.67	0.24	4.11	0.08	0.1	2,07	< 0,05
9	Flamingo balance test	9	0,45	8	0.11	0.1	9,89	< 0,05
				7th grade				
1	60 m sprint (s)	6.06	0.4	5.9	0.1	0.1	0,03	< 0,01
2	Steady running 1000 (m)	4.36	0.32	5.8	0.26	0.2	0,22	< 0,05
3	Pull-ups on a horizontal bar	5.33	0.67	6.0	0.41	0.3	0,09	< 0,05
4	Handgrip dynamometry	12.48	1.02	13.19	1.01	0.1	0,5	< 0,05
5	Sit-ups in 1 minute	29.57	0.32	31.83	0.59	0.1	0,37	< 0,05
6	Standing long jump(c)	149,17	1.56	152,0	2,9	0,7	0,13	< 0,05
7	4 × 9 m shuttle run(s)	11,3	0.15	11.0	0.15	0.2	0,1	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	4.33	0.21	4.54	0.15	0.1	1,01	< 0,05
9	Flamingo balance test	8	0.23	7	0.01	0.3	9.19	< 0,01
				8th grade				
1	60 m sprint (s)	9.6	0.2	9.4	0.3	0.3	0,2	< 0,05
2	Steady running 1500 (m)	7.6	0.3	7.30	0.2	0.1	0,2	< 0,01
3	Pull-ups on a horizontal bar	3.5	2.5	6.0	0.3	0.1	0,19	< 0,05

4	Handgrip dynamometry	19.98	1.3	21.27	0.2	0.1	0,1	< 0,05
5	Sit-ups in 1 minute	32,63	0.15	33.96	0.46	0.1	0.1	< 0,05
6	Standing long jump(c)	160.19	0.5	162.0	0.8	0.3	0,3	< 0,05
7	4 × 9 m shuttle run(s)	11.15	0.55	11.0	0.1	0.1	0,2	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	5.33	1.2	6.0	0.1	0.2	0,1	< 0,05
9	Flamingo balance test	7	0.14	6	0.1	0.2	6.93	< 0,01
				9th grade				
1	60 m sprint (s)	10.24	0.2	10.00	0.1	0.1	0,1	< 0,05
2	Steady running 1500 (m)	7.38	0.3	7.10	0.1	0.2	0,1	< 0,01
3	Pull-ups on a horizontal bar	4.2	2.5	8.0	0.2	0.3	0,1	< 0,05
4	Handgrip dynamometry	21.00	1.1	22.53	0.1	0.1	0,1	< 0,05
5	Sit-ups in 1 minute	33,63	1,8	36,86	0.21	0.13	0.1	< 0,05
6	Standing long jump(c)	174.00	0.5	178.0	0.3	0.2	0,2	< 0,05
7	4 × 9 m shuttle run(s)	10.47	0.55	10.3	0.3	0.1	0,2	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	6.23	1.2	7.0	0.2	0.3	0,1	< 0,05
9	Flamingo balance test	6	0.14	5	0.1	0.2	7.37	< 0,01

X – Arithmetic mean; s – Standard deviation; Δx – marginal sampling error for mean / confidence sampling error or marginal error; t – is Student's t test

Table 2. Indicators of physical fitness of girls of 5th–9th grades (n = 150)

n	Test	Before the experiment		After the experiment		Δx	t	p
		X	s	X	s			
				5th grade				
1	30 m sprint (s)	7.07	7.3	7.3	0.68	0.3	0,4	< 0,05
2	Steady running 400 (m)	648	53	700	0.1	0.2	0,2	< 0,01
3	Bending and extending the arms in a lying position	15.97	0.76	16.0	0.2	0.34	0,35	< 0,05
4	Handgrip dynamometry	5,55	1.03	6.17	0.56	0.02	1,12	< 0,05
5	Sit-ups in 1 minute	22.40	2.32	24.30	1.17	0.1	1,35	< 0,05
6	Standing long jump(c)	120.25	6.0	125.0	2.09	1.1	2,50	< 0,05
7	4 × 9 m shuttle run(s)	13.14	0.52	13.00	0.18	0.11	0,03	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	4.4	2.22	4.9	1.11	0.2	2,27	< 0,05
9	Flamingo balance test	17	2.3	15	1.01	0.02	10,28	< 0,01
				6th grade				
1	60 m sprint (s)	6.29	0.15	6.0	0.2	0.2	0,04	< 0,05
2	Steady running 500 (m)	855	145	1000	0.34	0.3	0,1	< 0,01
3	Bending and extending the arms in a lying position	17.45	0.3	18.1	0.1	0.1	0.13	< 0,05
4	Handgrip dynamometry	15.23	0.12	16.17	0.01	0.01	0.05	< 0,05
5	Sit-ups in 1 minute	23.67	1.32	26.17	0.7	0.1	0,5	< 0,05
6	Standing long jump(c)	140.67	1.13	145.0	1.0	1.0	2,13	< 0,05
7	4 × 9 m shuttle run(s)	12.18	0.7	12.0	0.24	0.1	0,02	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	4.67	0.24	5.01	0.08	0.1	2,07	< 0,05
9	Flamingo balance test	12	0.45	10	0.11	0.1	9,89	< 0,01

				7th grade				
1	60 m sprint (s)	6.06	0.4	5.9	0.1	0.1	0,03	< 0,01
2	Steady running 1000 (m)	4.36	0.32	5.8	0.26	0.2	0,22	< 0,05
3	Bending and extending the arms in a lying position	18.05	0.1	20.0	0.2	0.1	0.3	< 0,05
4	Handgrip dynamometry	18.48	1.02	20.19	1.01	0.01	0,5	< 0,05
5	Sit-ups in 1 minute	25.15	0.2	26.15	0.2	0.4	0,1	< 0,05
6	Standing long jump(c)	146.17	1.56	149.0	2.9	0.7	0,13	< 0,05
7	4 × 9 m shuttle run(s)	12.15	0.15	12.0	0.15	0.2	0,1	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	5.33	0.21	5.54	0.15	0.1	1,01	< 0,05
9	Flamingo balance test	9	0.23	9	0.01	0.3	9,19	< 0,01
				8th grade				
1	60 m sprint (s)	9.6	0.2	9.4	0.3	0.3	0,2	< 0,05
2	Steady running 1000 (m)	7.6	0.3	7.30	0.2	0.1	0,2	< 0,01
3	Bending and extending the arms in a lying position	19.98	1.3	21.27	0.2	0.1	0,1	< 0,05
4	Handgrip dynamometry	19.98	1.3	21.27	0.2	0.1	0,1	< 0,05
5	Sit-ups in 1 minute	31.45	0.1	32.18	0.1	0.1	0,1	< 0,05
6	Standing long jump(c)	149.17	0.5	155.0	0.8	0.3	0,3	< 0,05
7	4 × 9 m shuttle run(s)	12.0	0.55	11.30	0.1	0.1	0,2	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	5.33	1.2	7.0	0.1	0.2	0,1	< 0,05
9	Flamingo balance test	9	0.14	8	0.1	0.2	6,93	< 0,01
				9th grade				
1	60 m sprint (s)	10.24	0.2	10.00	0.1	0.1	0,1	< 0,05
2	Steady running 1000 (m)	7.38	0.3	7.10	0.1	0.2	0,1	< 0,01
3	Bending and extending the arms in a lying position	21.03	0.3	22.26	0.1	0.1	0,1	< 0,05
4	Handgrip dynamometry	21.00	1.1	22.53	0.1	0.1	0,1	< 0,05
5	Sit-ups in 1 minute	31.10	1.1	32.02	0.2	0.2	0,2	< 0,05
6	Standing long jump(c)	160.00	0.5	163.0	0.3	0.2	0,2	< 0,05
7	4 × 9 m shuttle run(s)	11.37	0.55	11.0	0.3	0.1	0,2	< 0,05
8	Sit and reach test (forward bend from a sitting position);(c)	7.17	1.2	8.23	0.2	0.3	0,1	< 0,05
9	Flamingo balance test	7	0.01	6	0.1	0.2	0.37	< 0,01

X – Arithmetic mean; s – Standard deviation; Δx – marginal sampling error for mean / confidence sampling error or marginal error; t – is Student's t test

The first and seventh tests were determined in seconds (seconds, s), the second – in meters (m), the third and fifth – in number of times, the fourth – in conventional units stronger hand, the sixth, eighth – in centimeters, the ninth test – in the number of attempts.

The increase in results in speed among boys occurs up to the 7th grade. Further deterioration of indicators is observed. A similar trend is observed among girls (Fig. 1).

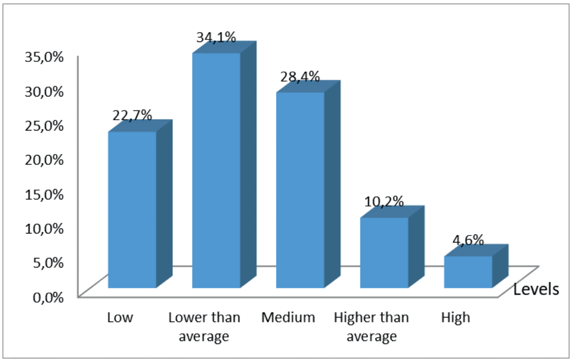


Fig. 1. Average speed indicators in children of 5th–9th grades, %

Endurance is characterized by a person's ability to perform work for a long time without reduction its performance. Overall endurance is based on the functions of the aerobic system, which includes cardiovascular, respiratory and circulatory.

In general, boys have a tendency to increase in endurance results, in the representatives of 5th, 7th and 9th grades, followed by stabilization and even a slight deterioration of the indicators. Girls have a similar tendency, with the highest increase in results occurring in the 5th and 6th grade representatives (Fig. 2).

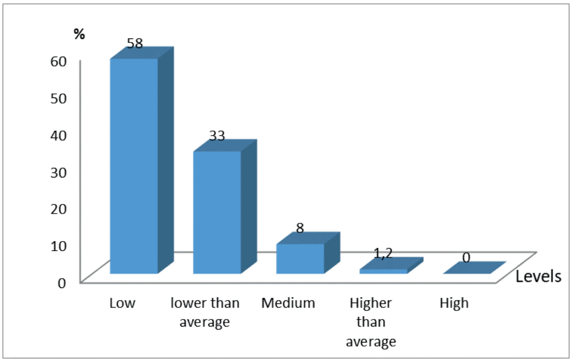


Fig. 2. Average indicators of the level of endurance in children of 5th–9th grades, %

Regarding the analysis of the results of students' strength abilities, we observe the following trend. During the pull-up test on the horizontal bar, boys showed improved results up to the 7th grade. A stabilization in strength development is observed in grades 7–8. From the 9th grade there is an increase in strength. In girls, there is an increase in strength to 9th grade (Fig. 3).

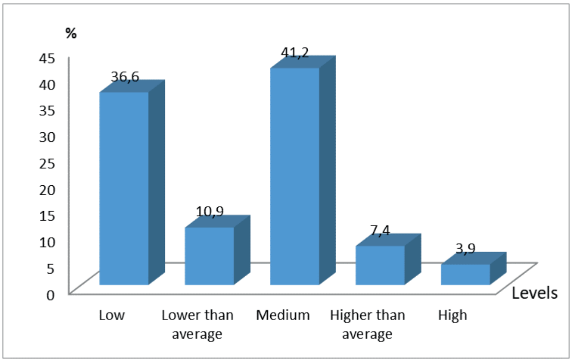


Fig. 3. Average indicators of the level of strength in boys of 5th–9th grades, %

An analysis of the strength level of girls when performing arm bending and extending test is presented on (Fig. 4).

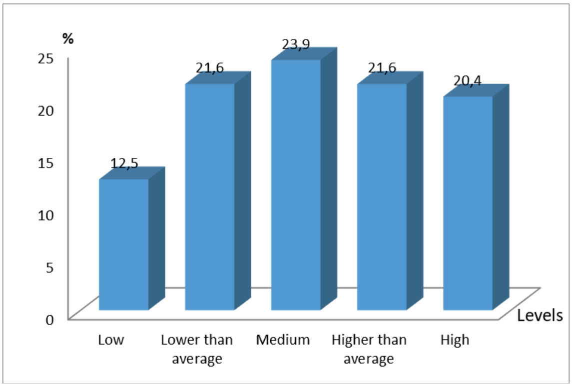


Fig. 4. Average indicators of strength level in girls of 5th–9th grades, %

It is established that the indexes of force (in particular – wrist dynamometry), in pupils of secondary schools of II and III degree are within the age norm and are estimated as average.

The results of the test «sit-ups» increase to the 6th–7th grade. A similar trend was found in the standing long jump. A moderate increase in speed-strength qualities is observed in boys in the 5th grade and in girls in the 9th grade. Boys show the most significant improvement in grades 8 and 10, while girls experience the greatest increase in grades 5–6.

Analyzing the results obtained in the test «standing long jump» for both boys and girls, there is an increase with age.

The analysis of the 4 × 9 m shuttle run test results indicated that boys exhibited performance improvements through the 6th grade, followed by a decline in the 7th grade, and subsequent improvement between the 8th and 9th grades.

A similar trend is observed in girls. Increased dexterity occurs up to 6th grade. In the 7th–8th grades stabilization takes place. In the 9th grade there is an increase in performance. In the 9th grade it gets worse. The analysis of indicators of the level of agility in students during the test «4 × 9 m shuttle run» is presented.

Analysis of the flexibility of students during the test «push-ups from a lying position» found that the results improve until the 7th grade. From the 8th to the 9th grade there is a decline in results.

The following trend is observed in girls. By the 7th grade there is an increase in flexibility. In the 8th and 9th grades stabilization occurs. It is worth noting that the rates of flexibility in girls are higher than in boys. This phenomenon is natural.

The Flamingo balance test is intended to assess statistical equilibrium. The results of our research showed that the average student performs this exercise from 3 to 14 attempts. Boys perform better than girls.

Discussion

The study was based on the indicators of test exercises, which are provided in the curriculum for physical education for secondary schools, grades 5–9. We determined the level of physical fitness of students. It was found that students have an average rate of physical fitness when performing tests to identify the development of strength, agility, flexibility and statistical balance. A significant percentage of children who have a low level of physical fitness was demonstrated when taking an endurance test. Below the average indicator of physical fitness among students of 5th – 9th grades was found when passing the speed test and in the control exercise «standing long jump». When passing the test «side torso lifts », a significant proportion of children showed above average level of physical fitness. No high level of physical fitness was found in any student.

The value of our study is that we identified which physical qualities are underdeveloped in schoolchildren. Therefore, in physical education lessons, teachers need to be given such exercises that would develop in children such motor skills as: endurance, speed and speed-strength abilities. The results of our research supplemented the data of Krutsevich (2003) on the periodic monitoring of the level of physical fitness of adolescents. It will allow the physical education teachers to see the shortcomings in the physical fitness of students and, if possible, individually plan physical activity, realistically assess the level of achievement and systematically adjust them. And for students it should be a stimulus of motivation for self-improvement of their physical abilities. Kuzmenko (2013) suggested reviewing the tests and requirements for them. The endurance test generally does not take into account time, for students of 5th–6th grades. Therefore, it is quite difficult to assess this quality in students. We share this view. Mameshina (2015) suggests that there is an urgent need today to develop a system of tests and standards of physical fitness for students. Test exercises must meet the age and appropriate standards of physical fitness. They should focus on a «safe» level of physical health. We support this view.

The results of other studies by Rodríguez. (2025) indicate that 41–44% of schoolchildren are characterized by a low level of physical fitness, and 33–34% – a very low level of physical fitness. Only 2% of students have a good level of physical fitness. Today, the physical fitness of students is at a low level. A particularly significant lag is observed in tests related to the manifestation of speed abilities and speed endurance. These students cannot fulfill the minimum regulatory requirements of the school program in physical education and quickly get tired, have lower functional abilities of the body.

Conclusions

The relevance of our research lies in the fact that it has revealed which physical qualities are underdeveloped in schoolchildren. This will help the physical education teachers to introduce appropriate adjustments to the pedagogical process to enhance the physical fitness of students.

Thus, studies have shown that children have an average level of physical fitness when performing tests to identify strength, agility, flexibility, and statistical equilibrium. A significant percentage of children with low fitness levels have been demonstrated with the endurance test. Below the average of physical fitness among students of 5th – 9th grades was found when passing the speed test and in the control exercise «standing long jump». When taking the «sit-up» test, a significant proportion of children demonstrated above average fitness. No high level of physical fitness was found in any student. The differences we have found in the level of motor performance are the basis for introducing a differentiated approach to the students in determining the optimal physical activity, volume and intensity of exercise for shaping a healthy lifestyle of students.

Funding This article didn't receive financial support from the state, public or commercial organizations.

Acknowledgments The authors express their gratitude for the participation to all respondents involved in the study.

References

Andrieieva, O., Kashuba, V., Carp, I., Blystiv, T., Palchuk, M., Kovalova, N., Khrypko, I. (2019). Assessment of emotional state and mental activity of 15-16 year-old boys and girls who had a low level of physical activity. *Journal of Physical Education and Sport, 19*(3), 1022–1029. https://doi.org/10.7752/jpes.2019.s3147

Andrieieva, O., Yarmak, O., Palchuk, M., Hauriak, O., Dotsyuk, L., Gorashchenco, A., Galan, Y. (2020). Monitoring the morphological and functional state of students during the transition from middle to high school during the physical education process. *Journal of Physical Education and Sport, 20*, 2110–2117. https://doi.org/10.7752/jpes.2020.s3284

Aperman-Itzhak, T., Yom-Tov, A., Vered, Z., Waysberg, R., Livne, I. & Eilat-Adar, S. (2018). School-Based Intervention to Promote a Healthy Lifestyle and Obesity Prevention Among Fifth- and Sixth-Grade Children. *Am. J. Health Educ. 49*, 289–295. https://doi.org/10.1080/19325037.2018.1486755.

Baranowski, T. (2017). Exergaming: Hope for future physical activity? or blight on mankind? J. *Sport Health Sci. 6*, 44–46. https://doi.org/10.1016/j.jshs.2016.11.006/

Drljačić, D., Arsić, K., & Arsić, D. (2012). Eurofit test battery for the assessment of physical abilities and health fitness in children. *PONS-medicinski časopis*, *9*(4), 158–164. https://doi.org/10.5937/pons1204158D.

Drozdovska, S., Andrieieva, O., Yarmak, O., & Blagii, O. (2020). Personalization of health-promoting fitness programs for young women based on genetic factors. *Journal of Physical Education and Sport, 20*, 331–337. https://doi.org/10.7752/jpes.2020.s1046.

Erhan, S. E. & Tamer, K. (2017). The relation between facilities and equipment for the course of physical education and sports and students' attitudes towards the course primary and secondary schools in Eastern Anatolia. *Atatürk Üniversitesi Beden Eğitimi ve Spor Bilimleri Dergisi*, *11*(3), 57–66. https://doi.org/10.15561/26649837.2020.0108.

Fedorov, A. I. & Sharmanova, S. B. [Eds.]. (2004). *Schoolchildren's health and behavior: Social and pedagogical monitoring of schoolchildren's health, physical activity and lifestyle*. Chelyabinsk: UralGAFK, ChGNOC Uro RAO. https://doi.org/10.1080/00313831.2021.1958376.

Grasten, A. (2017). School-based physical activity interventions for children and youth: Keys for success. J. *Sport Health Sci. 6*, 290–291. https://doi.org/10.1016/j.jshs.2017.03.001.

Greco, G.; Cataldi, S. & Fischetti, F. (2019). Effectiveness of a Short After-School Intervention on Physical Fitness in School-Aged Children. J. *Theor. Res. Edu. 14*, 143–164. https://doi.org/10.6092/issn.1970-2221/9217.

Hakman, A., Andrieieva, O., Kashuba, V., Nakonechnyi, I., Cherednichenko, S., Khrypko, I., Tomilina, Y., Filak, F., Moldovan A. (2020). Characteristics of biogeometric profile of posture and quality of life of students during the process of physical education. *Journal of Physical Education and Sport, 20*(1), 79–85. https://doi.org/10.7752/jpes.2020.01010.

Hynynen, S. T., van Stralen, M. M., Sniehotta, F. F., Araújo-Soares, V., Hardeman, W., Chinapaw, M. J. M., Vasankari, T. & Hankonen, N. A. (2016). Systematic review of school-based interventions targeting physical activity and sedentary behaviour among older adolescents. *Int. Rev. Sport Exerc. Psychol. 9,* 22–44. https://doi.org/10.1080/1750984X.2015.1081706.

Jongenelis, M. I., Scully, M., Morley, B., Pratt, I. S. & Slevin, T. (2018). Physical activity and screen-based recreation: Prevalences and trends over time among adolescents and barriers to recommended engagement. *Prev. Med.* 106, 66–72. https://doi.org/10.1016/j.ypmed.2017.10.006.

Krutsevich, T. (2003). *Theory and methodology of physical education.* Olympic Literature.

Kuzmenko, I. (2013). *Development of coordination abilities of middle-school students taking into account the functional state of sensory functions.* Kharkiv: KNU.

Mameshina, M. A., Maslyak, I. P. & Zhuk, V. A., [Eds.]. (2015). State and problems of physical education in regional general educational institutions: *Slobozhansk Scientific and Sport Bulletin; 3* (47), 52–57. https://doi.org/10.15391/snsv.2015-3.009.

Minatto, G., Petroski, E. L., Silva, K. S. D. & Duncan, M. J. (2019). School-Based Intervention on Cardiorespiratory Fitness in Brazilian Students: A Nonrandomized Controlled Trial. J. *Funct. Morphol. Kinesiol. 4*, 10. https://doi.org/10.3390/jfmk4010010.

Panhelova, N. & Tsapuk, D. (2018). Application of elements of oriental wellness systems in physical education of older preschool children: a theoretical and methodological aspect. *Sportivnij visnik Pridniprov'ia, 2*, 107–111.

Petrachkov, O., Yarmak, O., Biloshitskiy, V., Andrieieva, O., Mykhaylov, V., Chepurnyi, V., Malakhova, O. (2022). The influence of morphofunctional condition on the physical fitness level of Ukrainian soldiers. *Journal of Physical Education and Sport, 22*(9), 2182–2189. https://doi.org/10.7752/jpes.2022.09278.

Pbert, L., Druker, S., Barton, B., Schneider, K. L., Olendzki, B., Gapinski, M. A., Kurtz, S. & Osganian, S. A. (2016). School-based program for overweight and obese adolescents: A randomized controlled trial. J. *Sch. Health, 86*, 699–708. https://doi.org/10.1111/josh.12428.

Physical education curriculum for secondary schools. Grades 5 - 9. MONU; from 07.06.2017 № 804.

Rodríguez, G. S., Vergara, F. V., Osorio, S. V. & Mejías, J. T. (2025). Physical fitness of schoolchildren in the Metropolitan Region of Santiago: comparative analysis between types of educational establishments. *Federación Española de Asociaciones de Docentes de Educación Física (FEADEF). Retos*, 62, 155–160.

Tian, H. L., du Toit, D. & Toriola, A. L. (2017). The effects of an enhanced quality Physical Education programme on the physical activity levels of Grade 7 learners in Potchefstroom, *South Africa. Phys. Educ. Sport Pedagog. 22*, 35–50. https://doi.org/10.1080/17408989.2015.1072509.

To, Q. G., Wharton, L., Gallegos, D., Stylianou, M., Do, D. V., To, K. G., Tran, H. T. M. & Trost, S. G. (2019). School-based physical education: Physical activity and implementation barriers in Vietnamese elementary schools. *Eur. Phys. Educ. Rev*, 15–17.

Van de Kop, J. H.; van Kernebeek, W. G.; Otten, R. H. J.; Toussaint, H. M. & Verhoeff, A. P. (2019). School-Based Physical Activity Interventions in Prevocational Adolescents: A Systematic Review and Meta-Analyses. J. *Adolesc. Health, 65*, 185–194. https://doi.org/10.1016/j.jadohealth.2019.02.022.

Yarmak, O., Blagii, O., Palichuk, Y., Hakman, A., Balatska, L., Moroz, O. & Galan, Y. (2018). Analysis of the factor structure of the physical condition of girls 17-19 year old. *Journal of Human Sport and Exercise, 13* (2proc): 259–268. https://doi.org/10.14198/jhse.2018.13.Proc2.1.

Yelizarova, O., Stankevych, T., Parats, A., Antomonov, M., Polka, N. & Hozak, S. (2020). Specific features of the Ukrainian urban adolescents' physical activity: A cross-sectional study. *Journal of Environmental and Public Health,* Art. ID 3404285. https://doi.org/10.1155/2020/3404285.

Yuksel, H. S. (2019). Experiences of Prospective Physical Education Teachers on Active Gaming within the Context of School-Based Physical Activity. *Eur. J. Educ. Res. 8*, 199–211. https://doi.org/10.12973/eu-jer.8.1.199.

WHO. (2019). Global Strategy on Diet, Physical Activity and Health. Available online: https://www.who.int/ dietphysicalactivity/childhood/en/ (accessed on 15 September 2019).

WHO. (2019). Obesity and Overweight. Available online: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed on 10 September 2019).

WHO. (2019). What Is Overweight and Obesity? Available online: https://www.who.int/dietphysicalactivity/ childhood_what/en/ (accessed on 23 September 2019).

WHO. (2019). Report of the Commission on Ending Childhood Obesity. Available online: https://apps.who.int/iris/bitstream/handle/10665/204176/9789241510066_eng.pdf (accessed on 13 September 2019).

Cite this article as: Bakiko, I., Kovalchuk, V., Savchuk, S., Faidevych, V., Volchinskiy, A., Valkevich, O., & Krypliuk, O. (2025). Control of Physical Fitness of 5th–9th Grades School Students. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 47–58. https://doi.org/10.18276/cej.2025.3-04

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025: 59–72
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-05

CORRELATION STUDY BETWEEN OXYGEN CONSUMPTION AND BODY COMPOSITION IN PROFESSIONAL SOCCER PLAYERS AND NON-ATHLETE POPULATIONS WITH AND WITHOUT ANTERIOR CRUCIATE LIGAMENT RUPTURE

Jorge Enrique Buitrago-Espitia[A, B, C, D]

Universidad Industrial de Santander, Colombia
ORCID: 0000-0003-4490-7774 | e-mail: joebuies@uis.edu.co

Joseph Alejandro Rincón-Ramírez[B, C, D]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0002-6995-7965

Laura del Pilar Prieto Mondragón[A, B, D]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0002-9140-3598

Jeansy Alonso Rodríguez Buitrago[A, B]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0003-3093-7198

Diego Alonso Sánchez Rodríguez[C, D]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0003-4110-1572

Néstor David Ochoa Reyes[B, D]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0001-8360-9361

Néstor Ordoñez Saavedra[D, E]

Universidad de Ciencias Aplicadas y Ambientales, Colombia
ORCID: 0000-0002-5590-7406

Wilson Alexander Sierra Arévalo[A, B, D]

Universidad Escuela Colombiana de Ingeniería Julio Garavito, Colombia
ORCID: 0000-0002-1528-7978

Carlos Alberto Suárez Forero[B, C, D]

Fortaleza CEIF, Colombia
ORCID: 0000-0003-4740-6633

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection.

Abstract Introduction: Anterior Cruciate Ligament Rupture (ACLR) in athletes tends to increase annually. Maximal Oxygen Consumption ($\dot{V}O_2$ max) and Body Composition (BC) characteristics influence athletic performance. Purpose: The aim of this study was to analyse the correlation between oxygen consumption and body composition in professional soccer players and non-athletes with and without anterior cruciate ligament rupture. Methods: A Cardiopulmonary Exercise Testing (CPET) was performed to measure the cardiorespiratory capacity of 15 professional soccer players (1 ACLR), age 22.47 ±3.16 years, weight 74.69 ±6.04 kg, height 177.97 ±6.85 cm and 22 non-athlete participants (7 ACLR), age 22.27 ±3.09 years, weight 68.1 ±10.28 kg, height 172.44 ±5.66 cm. Results: Soccer players had higher VO_2 values (L/min) than non-athletes 3.55 ±0.33 vs. 3.23 ±0.38 ($p < 0.05$). Heart rate (/min) was significantly higher in non-athletes than in soccer players 184.35 ±14.11 vs. 182.91 ±14.04. In the non-athletes group (CG), participants without ACLR had higher VO_2/kg (ml/min/kg) than ACLR. Conclusion: Most of the body composition variables correlated significantly with $\dot{V}O_2$Peak (L/min) in both groups. These results demonstrate that an adequate body composition influences the oxygen consumption capacity of professional soccer players and non-athletes, this is relevant in athletes because as stated in previous studies, fatigue is a risk factor for ACL injury.

Key words: sports performance, return to play, knee injury, ergospirometry

Introduction

Several studies highlight the high rate of ACLR in professional soccer players (Balendra et al., 2022; Forsythe et al., 2021; Waldén et al., 2016) and an annual increase in this injury has even been reported in Major League Soccer between 1996 and 2012 (Erickson et al., 2013). ACLR is common among knee injuries suffered by professional soccer players, as well as in other sports, threatening the careers of many athletes (Balendra et al., 2022; Erickson et al., 2013). The surgical procedure is usually used to reconstruct the ACL and advanced rehabilitation procedures allow players to return to sports practice at specific times (Balendra et al., 2022), Using the Knee Injury and Osteoarthritis Outcome Score (KOOS), it was reported that after six months the scores stabilised, which could indicate that this period of time would be sufficient to return to play (Zaffagnini et al., 2014), but some complications can prolong the stages of rehabilitation and return to play between 9 to 12 months (Balendra et al., 2022; Zaffagnini et al., 2014; Waldén et al., 2016; Erickson et al., 2013; Kyritsis et al., 2015; Ardern et al., 2014; Grassi et al., 2020) and even 4% or 5% returned up to two or three years after the injury (Forsythe et al., 2021). Furthermore, it is common for athletes to develop abnormal patterns of strength, proprioception, balance, and neuromuscular control after ACL reconstruction (Dai et al., 2014), adding to the increased risk of chronic knee instability, meniscus injury, cartilage injury, and the development of osteoarthritis (LaBella et al., 2014; Waldén et al., 2016; Erickson et al., 2013).

High values of $\dot{V}O_2$ max can delay the onset of fatigue capable of affecting neuromuscular control (Khalid et al., 2015). $\dot{V}O_2$ max is considered a reliable method to evaluate aerobic capacity, which is essential for the performance of soccer players and their rapid recovery capacity post-competition (Marcos et al., 2018; Tonnessen et al., 2013; Aksoy et al., 2022; Modric et al., 2020).

Average $\dot{V}O_2$ max values are between 50 and 75 mL*kg-1*min-1 necessary for the aerobic capacity demands in men's professional soccer (Tonnessen et al., 2013; Modric et al., 2020). In moderate altitude conditions, values of 50 ±6.9 mL*kg-1*min -1 were reported in 1106 soccer players evaluated between 1998 and 2014 (Roa et al., 2015).

The development of aerobic capacity is essential for rapid post-competition recovery (Aksoy et al., 2022), the effort during a soccer match can generate an inflammatory response due to muscle damage and consequently reduce performance for 24 to 72 hours, according to the role of the player (Poulios et al., 2018), it has been considered that aerobic capacity may be a risk factor for injury because fatigue and inadequate recovery alter muscle control patterns and predispose individuals to possible injuries (Watson et al., 2017). On the other hand, it has been suggested that body composition may be associated with the risk of injury (Watson et al., 2017), and has an influence on aerobic capacity, which may also vary according to the playing position (full-backs, midfielders, attackers, central defenders, goalkeepers), the moment of preparation in which it is measured (preseason, season, end of season), the level of the players (professionals or third to fifth division) (Marcos et al., 2018), or after an ACL injury (Almeida et al., 2018). The aim of this study was to analyse the correlation between oxygen consumption and body composition in professional soccer players and non-athletes with and without anterior cruciate ligament rupture.

Methods

Selection of participants

Participants were selected by non-probabilistic sampling and distributed into two groups: Professional Soccer Players (SPG) (n = 15, age 22.47 ±3.16 years, the sporting age was 16.8 ±2.7 years, they compete in the highest level tournaments of Colombian soccer on average twice a week: Colombian professional league and Colombian cup, some have competed in clubs in other countries and were called up to the national team for the U20 world championships. They train on average 30 hours per week), and healthy non-athletic participants (CG) (n = 22, 22.27 ±3.09 years) were included.

The study was approved by the Research Committee on 7 December 2020, Act 145 of the Universidad de Ciencias Aplicadas y Ambientales U.D.C.A. The participants in both groups signed an informed consent form. Inclusion and exclusion criteria for participants were: being over 18 years old with or without a history of ACLR. When they reported an ACLR, they were required to have completed rehabilitation and have medical approval to return to sports activity. In CG, physical activity levels were estimated with the International Physical Activity Questionnaire (IPAQ) short version (Craig et al., 2003). People were excluded if: a) they report a history or suffer from neurological, motor (neuromuscular) or cognitive disorders, b) they have a BMI >35, c) they report any cardiovascular alteration, d) inability to perform the test, e) or without medical endorsement for return to normal physical practice.

Data collection

Before the test, participants were asked to avoid high-intensity exercise or training 24 hours before the test, to avoid drinks with caffeine or alcohol on the day of the test, and to wear comfortable sports clothing and shoes for the test.

Anthropometric height measurements were taken from the participants with a Seca 213 Stadiometer (Measuring range 20–205 cm, Hamburg, Germany) and body composition by Bioimpedance with the Tanita BC-1500 scale (maximum capacity 150 kg d = 0.1 kg, Japan). All tests were carried out in one week, soccer players (SPG) were evaluated at the beginning of the 2022-2 pre-season, on one day starting at 8:00 am and ending at 4:00 pm. The non-athletic individuals (CG) were evaluated for three days at the same time as the soccer players. The tests were carried out by the same researchers (JB, JR, NO, AS, CS), who have the expertise to use the instruments and carry out the measurements.

The test was carried out in the laboratory at room temperature 16–18º C, relative air humidity ≈ 60%, barometric pressure between 690 to 710 mmHg and 2600 m altitude (moderate altitude), Bogotá, Colombia. The amount of oxygen (O_2) consumed, carbon dioxide (CO_2) produced, and lung ventilation (VE) were measured breath-by-breath with a Metalyzer 3B computerized gas exchange analysis system (Cortex Biophysik GmbH, Leipzig, Germany) and were analyzed with the Metasoft™ program. Before each test, the Cortex unit was calibrated with a previously known gas sample (16% O_2 and 5% CO_2).

Cardiopulmonary Exercise Testing (CPET) was performed using a motorized treadmill, maintaining an incline of 1%, the test included three phases: 1) a 3-minute warm-up walking at 4 km*h-1, 2) the exercise began at 4 km*h-1 followed in increments of 1 km*h-1 every 90 seconds until exhaustion. Verbal encouragement was used at the end of the test. 3) The recovery phase was 3 minutes of walking at 4 km*h-1. Heart rate was measured with a Polar band linked to Metasoft™ software.

Criteria for reaching $\dot{V}O_2$ max it is: a) voluntary exhaustion, b) reaching at least 90% ±5% of the maximum heart rate (Midgley et al., 2007), c) rate of respiratory exchange greater than 1.15, d) $\dot{V}O_2$ max identified by the plateau phase (difference between the last stages < 0.05 L*min -1) and confirming that $\dot{V}O_2$ max increase was less than 2 ml/kg/min between two consecutive stages at peak exercise (Neto et al., 2022).

$\dot{V}O_2$ max was quantified by a sports physician (CS). Ventilatory thresholds (VT1) were determined when the lowest ventilatory oxygen equivalent ($VE/\dot{V}O_2$) was observed before its continuous increase, and the lowest end-tidal oxygen pressure ($PETO_2$) before its continuous increase. The ventilatory threshold (VT2) was determined when the lowest ventilatory carbon dioxide equivalent (VE/VCO_2) was observed before its continuous increase and the highest expiratory carbon dioxide pressure ($PETO_2$) before the abrupt fall (second inflection point of the curves in progressive exercise). This is the transition between stable and heavy rhythms (Almeida et al., 2018).

Analysis of Ventilatory Thresholds

Anaerobic threshold (AT) values were determined using the V-Slope method (Lin et al., 2020). The AT was identified at the intersection of the two straight lines describing the relationship between carbon dioxide production (VCO_2) and oxygen consumption ($\dot{V}O_2$). The determination is performed through regression analysis, where the point of intersection of the regression lines are systematically moved across the data range. The final AT is designed at the location where the remaining sum of squares is minimized (Santos & Giannella-Neto, 2004). This method allows for a precise and objective identification of the metabolic transition point during incremental exercise, providing insights into the physiological threshold between aerobic and anaerobic metabolism.

Statistical analysis

The data were processed with IBM SPSS Corp. 2017. IBM SPSS Statistics for Windows, Version 25. The Shapiro-Wilk test verified the normal distribution of the data. The Student T test for independent samples allowed us to compare the averages of both groups in each variable, the Mann-Whitney U test for independent samples was used in the variables that did not have a normal distribution (non-parametric test). The Pearson test was used to establish the correlation between the variables with normal distribution in consistency with the ranges of 0 null, between 0.01 to 0.20 low; 0.21 to 0.40 weak; between 0.41 to 0.60 average; between 0.61 to 0.80 medium-high; between 0.81 to 0.99 high, 1 perfect, regardless of whether it is positive or negative. Spearman's rank correlation coefficient (non-parametric) was used for variables without normal distribution.

Results

Thirty-seven participants (n = 37) were evaluated, distributed in a group of professional soccer players (SPG) n = 15 (14 without ACLR, 1 ACLR), age 22.47 ±3.16. years, weight 74.69 ±6.04 kg, height 177.97 ±6.85 cm, and the control or non-athlete group (CG) n = 22 (15 without ACLR, 7 ACLR), age 22.27 ±3.09 years, weight 68.1 ±10.28 kg, height 172.44 ±5.66 cm. In the CG, the results of the IPAQ questionnaire showed an average of 356.46 ±187.74; 294.86 ±88.14 and 294.03 ±108.31 min of intense and moderate physical activity and time spent walking per week respectively, while the sitting time on a working day was 184.45 ±117.44 minutes.

The normality of the data in each variable was checked with the Shapiro-Wilk test in SPSS, α = 0.05 (5%) was established. Twenty-eight variables were analysed that describe the general characteristics, body composition and cardiorespiratory capacity of the participants. Eight variables did not have a normal distribution: age (yrs), body fat mass (kg), visceral fat rating, $\dot{V}O_2$/HR (ml), HR (min), Vmax. (km/h), VT (L), FR (min), these data were analysed with non-parametric tests, the results are shown in Table 1.

Table 1. Comparison of non-normally distributed variables in both groups (mean ± standard deviation).

Variables	SPG (n = 15)	CG (n = 22)	p-value
Age (yrs)	22.47 ±3.16	22.27 ±3.09	0.658 NS
Body fat mass (kg)	11.21 ±3.88	10.36 ±4.52	0.262 NS
Visceral fat rating	2.67 ±1.59	2.43 ±1.71	0.366 NS
$\dot{V}O_2$/HR (ml)	19.61 ±4.76	19.27 ±4.6	0.002*
HR (/min)	182.91 ±14.04	184.35 ±14.11	0.002*
Vmax (km/h)	15.12 ±1.22	15.08 ±1.21	0.319 NS
VT (L)	2.6 ±0.4	2.61 ±0.38	0.963 NS
RF (/min)	57.43 ±13.26	56.81 ±12.84	0.127 NS

Asymptotic significance is shown. The significance level is 0.05. * The exact significance for this test is shown. NS: Not Significant. $\dot{V}O_2$: Oxygen Consumption. HR: Heart Rate. V: Velocity. VT: Ventilatory threshold. RF: Respiratory Frequency.

The Mann-Whitney U-test for independent samples showed that $\dot{V}O_2$/HR (ml), and HR (/min) had significant differences. The characteristics of the variables in each group are shown in Table 2.

Table 2. Comparison of variables among SPG and CG groups (mean ± standard deviation).

Variables	SPG (n = 15)	CG (n = 22)	p-value	Mean difference
Weight (kg)	74.69 ±6.04	68.1 ±10.28	0.033*	6.582
Height (cm)	177.97 ±6.85	172.44 ±5.66	0.011*	5.530
BMI (kg/m2)	24.11 ±1.94	22.9 ±2.66	0.142 NS	1.209
Body fat (%)	14.87 ±4.5	13.91 ±5.12	0.561 NS	0.960
Fat-free mass (kg)	63.48 ±5.12	57.9 ±7.35	0.016*	5.575
Body water (%)	61.03 ±3.41	62.05 ±4.35	0.456 NS	–1.012
Body water mass (kg)	45.51 ±3.62	42.00 ±4.46	0.016*	3.511
Muscle mass (kg)	60.34 ±4.89	55.39 ±6.55	0.018*	4.954
Bone mass (kg)	3.17 ±0.23	2.93 ±0.31	0.020*	0.235
BMR (kcal)	1879.6 ±144.49	1729.95 ±203.16	0.019*	149.645
$V'O_2$Peak (L/min)	3.55 ±0.33	3.33 ±0.34	0.056 NS	0.226
VO_2 (L/min)	3.55 ±0.33	3.23 ±0.38	0.013*	0.321
$V'O_2$/kg (ml/min/kg)	48.2 ±3.09	48.27 ±4.84	0.959 NS	–0.072
Duration (min)	20.7 ±1.17	21.32 ±1.84	0.262 NS	–0.616
$VE/V'O_2$	42.36 ±4.6	40.91 ±4.19	0.328 NS	1.448
VE/VCO_2	35.09 ±2.8	36.83 ±2.86	0.076 NS	–1.743
RER	1.2 ±0.05	1.11 ±0.05	0.000*	0.087
VE (L/min)	159.38 ±20.2	144.04 ±19.22	0.025*	15.341
VT1 (L/min)	2.17 ±0.38	1.97 ±0.32	0.104 NS	0.197
VT2 (L/min)	2.86 ±0.36	2.85 ±0.39	0.934 NS	0.010

Note: * There are significant differences $p < 0.05$ between groups using T for independent samples. The duration of the test includes the three phases (warm-up, exercise, recovery). NS: Not Significant. BMI: Body Mass Index. BMR Basal Metabolic Rate. $V'O_2$: Oxygen consumption. $VE/V'O_2$: Ventilatory Oxygen Equivalent. VE/VCO_2: Ventilatory Carbon Dioxide Equivalent. RER: Respiratory Exchange Ratio. VE: Lung Ventilation. VT: Ventilatory threshold.

The SPG had greater height (cm) and body weight (kg) than the CG. In the body composition variables, there were also significant differences that demonstrate the effects of systematic training in soccer players: greater fat-free mass (kg), body water mass (kg), muscle mass (kg), bone mass (kg), basal metabolic rate (kcal) compared to CG.

There were no significant differences between the groups in BMI, body fat (%), and body water (%), $V'O_2$Peak (L/min), $V'O_2$/kg (ml/min/kg), Vmax (km/h), duration (min), $VE/V'O_2$, VE/VCO_2, VT (L), RF (/min), VT1 (L/min), VT2 (L /min). There were significant differences in $V'O_2$ (L/min), $V'O_2$/HR (ml), and VE (L/min) where the SPG results were superior to the CG. The only variable in which CG had a statistically significant higher value compared to SPG was HR (/min).

In SPG, one participant had ACLR in the working leg (right) when he was 22 years old. The athlete underwent reconstruction surgery and carried out the physical rehabilitation process for 6 to 9 months until returning to professional sports practice. He reported pain and inflammation as symptoms after the ACL injury, in addition, he had a meniscus injury before the ACL injury. This soccer player reached 3.73; 47; 15 and 20.33 in $V'O_2$Peak (L/min), $V'O_2$/kg (ml/min/kg), Vmax (km/h) and duration (min), respectively.

On the other hand, in the CG seven participants had ACLR: age 24.28 ±3.8 years, height 174.78 ±5.1 cm, weight 70.71 ±3.9 kg, age at which the injury occurred 20.42 ±2.3 years. All underwent reconstruction surgery and completed physical rehabilitation for 1 to 3 months (n = 3) and >3 to 6 months (n = 4). In addition, they reported medial collateral ligament injury (n = 3) and internal and/or external meniscus injury (n = 2) associated with the ACLR. The mechanism of injury was non-contact during a soccer game (n = 6) and contact (n = 1). Participants with

ACLR recorded 3.22 ±0.2; 44.86 ±2.7; 14.57 ±1.1 and 20.51 ±1.3 in $\dot{V}O_2$Peak (L/min), $\dot{V}O_2$/kg (ml/min/kg), Vmax (km/h) and duration (min), respectively.

The CG results were compared between participants with and without ACLR (Table 3).

Table 3. Comparison between participants with and without ACLR in the CG (mean ± standard deviation).

Variables	ACLR (n = 7)	No ACLR (n = 15)	p-value
$\dot{V}O_2$Peak (L/min)	3.22 ±0.02	3.37 ±0.16	0.33 NS
$\dot{V}O_2$/kg (ml/min/kg)	44.85 ±7.4	49.86 ±23.4	0.01*
Duration (min)	20.5 ±1.7	21.7 ±3.9	0.16 NS
VT1 (L/min)	1.91 ±0.05	2.07 ±0.13	0.54 NS
VT2 (L/min)	2.74 ±0.02	2.89 ±0.2	0.4 NS

Note: * There are significant differences $p < 0.05$ between groups using T for independent samples. NS: Not Significant. $\dot{V}O_2$: Oxygen consumption. VT: Ventilatory threshold.

The only variable in which there was a significant difference when comparing CG participants with or without ACL injury was relative oxygen consumption, where the result was higher in participants without ACL injury. In the other variables, the data are higher in the group without ACL injury, although the differences are not statistically significant.

Pearson's correlation test ($p \leq 0.05$) was used to find the correlation between normally distributed variables (Table 4).

Table 4. Correlation study oxygen consumption and body composition variables in both groups.

Groups	VO_2Peak SPG (n = 15)	VO_2Peak CG (n = 22)
Variable	**r**	**r**
Weight (kg)	0.709**	0.761**
Height (cm)	0.621*	0.461*
BMI (kg/m2)	0.153	0.710*
Body fat (%)	0.033	0.345
Fat-free mass (kg)	0.690**	0.799**
Body water (%)	–0.079	–0.416
Body water mass (kg)	0.671**	0.753**
Muscle mass (kg)	0.686**	0.756**
Bone mass (kg)	0.729**	0.750**
Basal metabolic rate (kcal)	0.679**	0.776**

**. The correlation is significant at the 0.01 level (two-sided).
*. The correlation is significant at the 0.05 level (two-sided).

Both SPG and CG groups had significant correlations between $\dot{V}O_2$Peak (L/min) and body composition variables. These results demonstrate that proper body composition is important for efficient oxygen consumption. The significant correlations found in each group are represented in the graphs below.

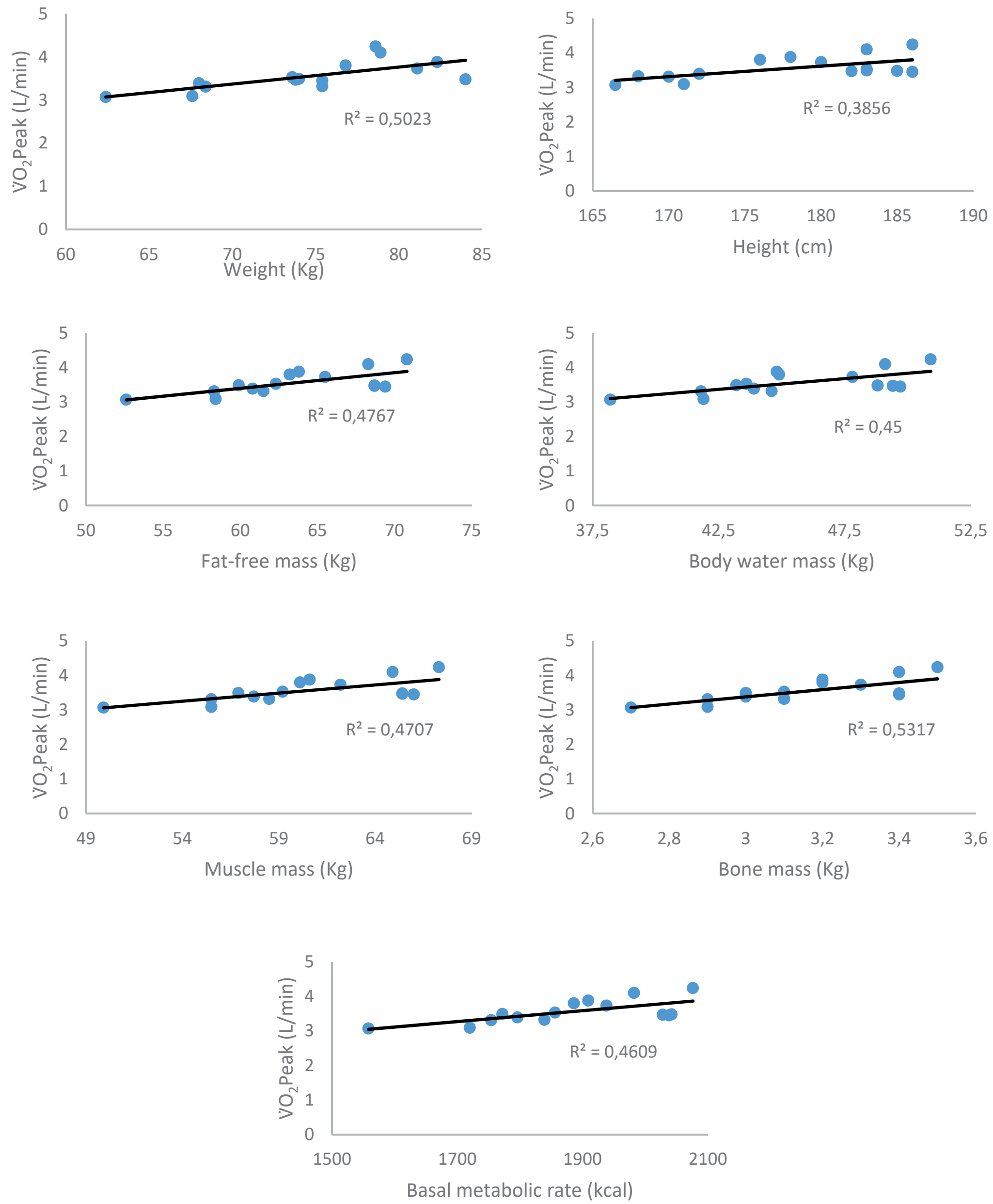


Fig. 1. Correlation between $\dot{V}O_2$Peak (L/min) and body composition variables SPG.

In SPG there was a medium-high correlation between $\dot{V}O_2$Peak (L/min) and weight (kg), height (cm), fat-free mass (kg), body water mass (kg), muscle mass (kg), bone mass (kg), BMR (kcal).

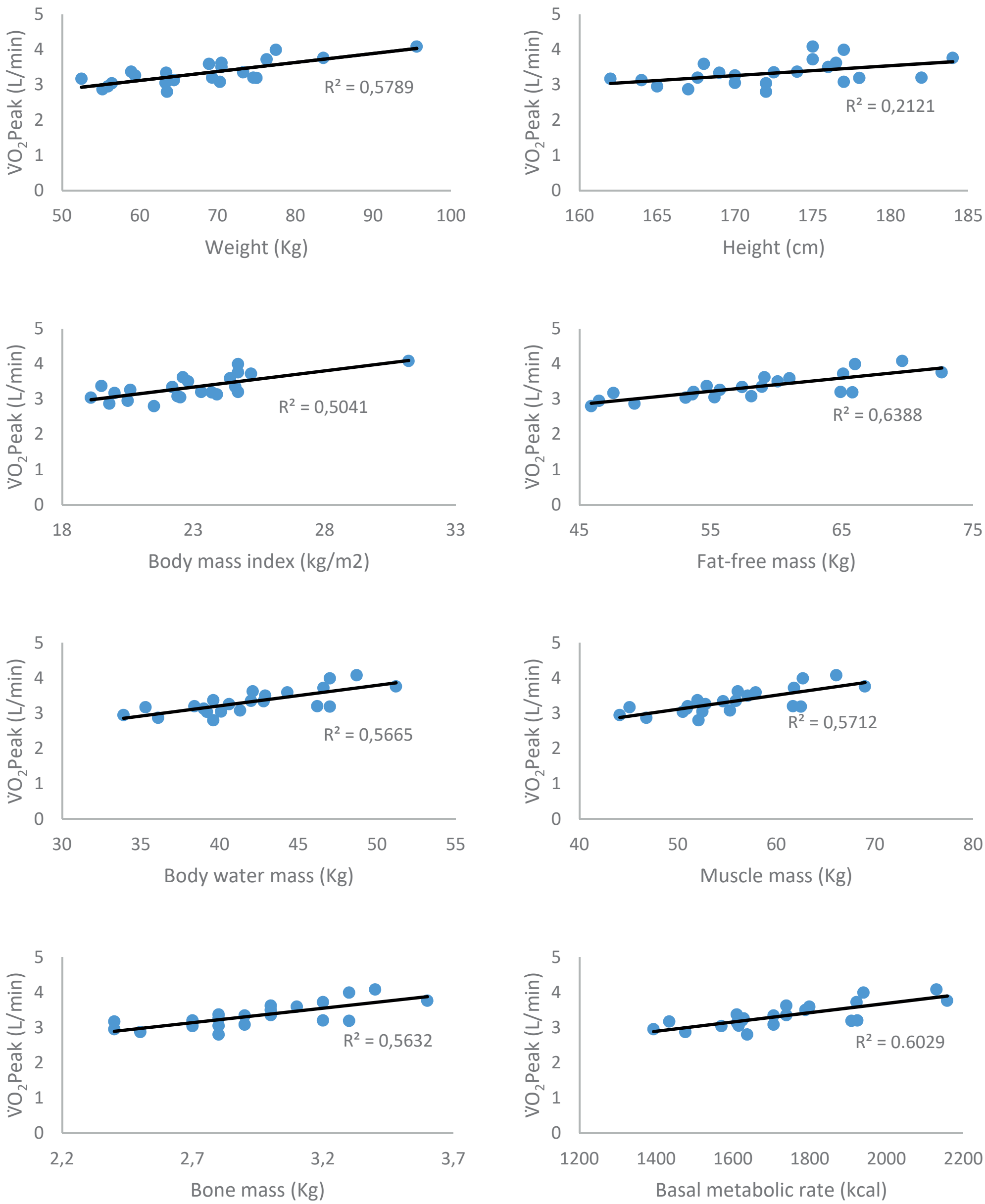


Fig 2. Correlation between $\dot{V}O_2$Peak (L/min) and body composition variables CG.

In CG there was a medium correlation between $\dot{V}O_2$Peak (L/min) and height (cm), and a medium-high correlation between $\dot{V}O_2$Peak (L/min) and weight (kg), BMI (kg/m2), fat-free mass (kg), body water mass (kg), muscle mass (kg), bone mass (kg), BMR (kcal). These results demonstrate that body composition variables can affect oxygen consumption capacity in professional athletes and non-athlete participants.

Discussion

The purpose of this study was to analyse the correlation between oxygen consumption and body composition in professional soccer players and non-athletes with and without anterior cruciate ligament rupture. According to the literature consulted, ACLR is caused by multiple factors including body composition (LaBella et al., 2014). Evaluating physical aspects in Colombian professional soccer players allows the characterisation of fundamental parameters (Blanco-Espitia et al., 2023), revealing distinctive physical characteristics of Latin American professional soccer players in comparison with their European peers (Da Silva et al., 2008). Comparative studies in professional soccer have shown variations in body fat percentages in different populations (Burns et al., 2018). Slimani & Nikolaidis (2019) identified body fat percentages of 11.2 ±4.3 % in healthy Icelandic first division soccer players, this percentage is lower than the result of the professional soccer players in this study (14.87 ±4.5%). Almeida et al. (2018), reported body fat percentages of 14.9 ±5.4 % for athletes with ACL rupture and 12.8 ±4.0 % for healthy athletes, these data are lower compared to the results of this study, whereas the soccer player with ACLR had 19.2% and healthy athletes had 14.6 ±4.5% body fat, highlighting significant variations in body composition between professional soccer players.

The relationship between body composition and cardiorespiratory fitness in population aged 18–70 years from Tehran, Iran was investigated by Davarzani et al. (2020) who found that participants with higher level of physical activity had significantly higher mean lean body mass ($p < 0.001$), right ($p < 0.001$) and left ($p < 0.001$) arm lean mass, skeletal muscle mass ($p < 0.001$) and bone mineral content ($p < 0.001$). They also found a significant negative relationship between physical activity level and fat mass ($p = 0.002$), body fat percentage ($p < 0.001$), visceral fat area ($p = 0.001$) and trunk fat ($p = 0.005$), demonstrating the lower amount of fat in the high physical activity group.

On the other hand, Robles Pino et al. (2019) in the analysis of the players of the U22 Peruvian national soccer team in 2015 found a positive correlation between VO_2 max and relative muscle mass (Spearman's Rho = 0.65; $p < 0.001$) and a negative correlation with relative adiposity (Spearman's Rho = –0.48; $p = 0.018$). While Castiblanco Arroyave et al. (2020) found a statistically significant correlation between cardio respiratory capacity, BMI and fat percentage in university athletes from Manizales (Colombia).

In the analysis of $\dot{V}O_2$ max, Slimani & Nikolaidis (2019) it was reported 59.2 to 66.6 ml/kg/min and 57.8 to 61.7 ml/kg/min in healthy elite and amateur male soccer players respectively. These data are higher than the results of the healthy soccer players in this study 48.3 ±3.2 ml/min/kg. Likewise, Almeida et al. (2018), reported a $\dot{V}O_2$ max of 48.9 ±3.8 ml/kg/min and 56.9 ±4.2 ml/kg/min in Brazilian soccer players with RLCA and healthy players respectively, these data exceed the results of the soccer player with RLCA in this study 47 ml/ min/kg and healthy athletes 48.3 ±3.2 ml/min/kg. However, the results of this study are close to the average of 50 ±6.9 mL*kg-1*min –1 reported in the measurements of soccer players between 1998 and 2014 in the Coldeportes Exercise Physiology Laboratory in Bogotá (Roa et al., 2015), although it is unknown at what time of the season the measurements were made. While Blanco-Espitia et al. (2023) reported $\dot{V}O_2$ max values of 53.2 ±4 ml/kg/min in 39 professional soccer players from Bogota estimated with the Leger test. Thus, information about oxygen consumption in soccer players at average height remains scarce and more studies are required to compare data at each stage of training.

Castagna et al. (2013) determined that the aerobic capacity necessary to meet the minimum requirements in men's professional soccer is 60 ml/kg/min, this value is higher than the result of the soccer players in this study 48.2 ±3.09 ml/min. kg/min. Therefore, soccer players require optimal aerobic capacity to sustain high-intensity repetitive actions, speed up recovery processes and maintain their physical performance during the competition time, which would be at least 90 minutes (Bangsbo, 2014; Faustino-da-Silva et al., 2020).

In the study by Teixeira et al. (2018) thresholds were measured in a maximum incremental exercise test on a motorized treadmill, reporting a VT1 = 2.71 ±0.32 (L/min), this result exceeds what we found in the soccer players in this study 2.17 ±0.38 L/min. On the other hand, it is said that VT2 is responsible for the efficiency of the buffer system and acid-base regulation to maintain the pH in the blood and peripheral muscles. In this regard, Sahlin (2014) determines that there is a significant improvement in the cushioning system (buffer) in subjects who perform post-injury rehabilitation exercises, interpreting that those who adhere to rehabilitation programs improve their VT2. At the second threshold, Teixeira et al. (2018) reported VT2 = 3.28 ±0.50 (L/min) in soccer players aged between 12.5 and 15.4 years, this result exceeds the 2.86 ±0.36 L/min achieved in VT2 by soccer players from present study.

A limitation of this study was the selection of a convenience sample (professional men's soccer team); therefore, selection bias exists and it is advisable to interpret these results with caution. However, it is important to analyse professional soccer players because information about these players is limited, specifically in conditions of moderate altitudes above sea level. Furthermore, it is advisable to carry out further measurements to evaluate the results over time in order to obtain more scientific evidence on this issue.

The data obtained in this study are considered valuable because the use of the cortex Metalyzer 3B Leipzig instrument confirms the validity of the results due to its high quality of monitoring. Validated results were obtained about the cardiorespiratory capacity of male professional soccer players, in the CG it was evident that $\dot{V}O_2$ max is significantly lower in participants with ACLR compared to healthy subjects.

Future research should focus on studying with larger randomized cohorts and longitudinally. Furthermore, this type of research should be carried out on female soccer players since the highest percentage of ACLR falls on the female gender.

Conclusion

The results of this study show that most of the body composition variables: weight (kg), height (cm), fat-free mass (kg), body water mass (kg), muscle mass (kg), bone mass (kg), BMR (kcal) have a significant correlation with $\dot{V}O_2$Peak (L/min) in both groups. These results demonstrate that an adequate body composition influences the oxygen consumption capacity of professional soccer players and non-athletes, this is relevant in athletes because as stated in previous studies, fatigue is a risk factor for ACL injury. As far as we know, this is one of the first studies conducted in Bogota, Colombia, to analyse oxygen consumption and body composition in professional soccer players and non-athletes with and without ACL injury. Therefore, the data obtained constitute a reference for future research on these topics in soccer.

In the body composition variables: weight (kg), height (cm), fat-free mass (kg), body water mass (kg), muscle mass (kg), bone mass (kg), BMR (kcal), SPG had significant results higher than CG. However, in the oxygen consumption variables only $\dot{V}O2$ (L/min) and VE (L/min) had significant differences. It is important to note that SPG was assessed in the first week of the pre-season, this may justify that the oxygen consumption values are close to those of non-athletes, but studies are required at other times of the season to verify these results.

Acknowledgments

The authors are grateful to the Universidad de Ciencias Aplicadas y Ambientales U.D.C.A. for providing the necessary means for the development of this study. To the Universidad Escuela Colombiana de Ingeniería Julio Garavito, institutions that financed the study. To the professional athletes of the Fortaleza CEIF, to the Sports Sciences students who made up the control group.

References

Aksoy, Ö., Bozdoğan, T. K., Soyal, M., & Beyaz, M. M. (2022). The examination of VO2MAX and anaerobic threshold values in elite soccer players by their positions. *Journal of Physical Education and Sport*, *22*(10), 2496–2503. https://doi.org/10.7752/jpes.2022.10317

Almeida, A. M. de, Santos Silva, P. R., Pedrinelli, A., & Hernandez, A. J. (2018). Aerobic fitness in professional soccer players after anterior cruciate ligament reconstruction. *PLOS ONE*, *13*(3), e0194432-. https://doi.org/10.1371/journal.pone.0194432

Ardern, C. L., Taylor, N. F., Feller, J. A., & Webster, K. E. (2014). Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. *British Journal of Sports Medicine*, *48*(21), 1543. https://doi.org/10.1136/bjsports-2013-093398

Balendra, G., Jones, M., Borque, K. A., Willinger, L., Pinheiro, V. H., & Williams, A. (2022). Factors affecting return to play and graft re-rupture after primary ACL reconstruction in professional footballers. *Knee Surgery, Sports Traumatology, Arthroscopy*, *30*(7), 2200–2208. https://doi.org/10.1007/s00167-021-06765-8

Bangsbo, J. (2014). Physiological demands of football. *Sports Science Exchange*, *27*(125), 1–6.

Blanco-Espitia, D. C., Blanco-Espitia, R. D., Gálvez-Pardo, A. Y., & Castro-Jiménez, L. E. (2023). Medición del consumo máximo de oxígeno en futbolistas profesionales de Bogotá. *Revista Digital: Actividad Física y Deporte*, *9*(1). https://doi.org/10.31910/rdafd.v9.n1.2023.2262

Burns, E. A., Collins, A. D., Jack, R. A., McCulloch, P. C., Lintner, D. M., & Harris, J. D. (2018). Trends in the Body Mass Index of Pediatric and Adult Patients Undergoing Anterior Cruciate Ligament Reconstruction. *Orthopaedic Journal of Sports Medicine*, *6*(4), 2325967118767398. https://doi.org/10.1177/2325967118767398

Castagna, C., Impellizzeri, F. M., Chaouachi, A., & Manzi, V. (2013). Preseason Variations in Aerobic Fitness and Performance in Elite-Standard Soccer Players: A Team Study. *The Journal of Strength & Conditioning Research*, *27*(11). https://journals.lww.com/nsca-jscr/fulltext/2013/11000/preseason_variations_in_aerobic_fitness_and.6.aspx

Castiblanco Arroyave, H. D., Vidarte Claros, J. A., & Parra Sánchez, J. H. (2020). Body composition and cardiorespiratory capacity in university athletes in Manizales (Colombia). *Nutricion Clinica y Dietetica Hospitalaria*, *40*(1), 12–19. https://doi.org/10.12873/401castiblanco

Craig, C., Marshall A. L., Sjöström M., Bauman A. E, Booth M. L., Ainsworth B. E., & et al. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*, *35*, 1381–1395. https://doi.org/10.2165/11531930-000000000

Da Silva, C. D., Bloomfield, J., Carlos, J., & Marins, B. (2008). A review of stature, body mass and maximal oxygen uptake profiles of U17, U20 and first division players in Brazilian soccer. In ©*Journal of Sports Science and Medicine* (Vol. 7). http://www.jssm.org

Dai, B., Mao, D., Garrett, W. E., & Yu, B. (2014). Anterior cruciate ligament injuries in soccer: Loading mechanisms, risk factors, and prevention programs. *Journal of Sport and Health Science*, *3*(4), 299–306. https://doi.org/10.1016/j.jshs.2014.06.002

Davarzani, S., Babaei, N., Ebaditabar, M., Djafarian, K., & Shab-Bidar, S. (2020). Associations of physical activity with cardiorespiratory fitness, muscle strength, and body composition. *Pediatric Endocrinology Diabetes and Metabolism*, *26*(4), 183–191. https://doi.org/10.5114/pedm.2020.98718

Erickson, B. J., Harris, J. D., Cvetanovich, G. L., Bach, B. R., Bush-Joseph, C. A., Abrams, G. D., Gupta, A. K., McCormick, F. M., & Cole, B. J. (2013). Performance and return to sport after anterior cruciate ligament reconstruction in male major league soccer players. *Orthopaedic Journal of Sports Medicine*, *1*(2). https://doi.org/10.1177/2325967113497189

Faustino-da-Silva, Y. V, Martinho, D. V, Coelho-e-Silva, M. J., Valente-dos-Santos, J., Conde, J., Oliveira, T. G., Ronque, E. R. V, Agostinete, R. R., Fernandes, R. A., & Sherar, L. B. (2020). Reproducibility and inter-observer agreement of Greulich-Pyle protocol to estimate skeletal age among female adolescent soccer players. *BMC Pediatrics*, *20*(1). https://doi.org/10.1186/s12887-020-02383-4

Forsythe, B., Lavoie-Gagne, O. Z., Forlenza, E. M., Diaz, C. C., & Mascarenhas, R. (2021). Return-to-Play Times and Player Performance After ACL Reconstruction in Elite UEFA Professional Soccer Players: A Matched-Cohort Analysis From 1999 to 2019. *Orthopaedic Journal of Sports Medicine*, *9*(5), 23259671211008892. https://doi.org/10.1177/23259671211008892

Grassi, A., Tosarelli, F., Agostinone, P., Macchiarola, L., Zaffagnini, S., & Della Villa, F. (2020). Rapid Posterior Tibial Reduction After Noncontact Anterior Cruciate Ligament Rupture: Mechanism Description From a Video Analysis. *Sports Health*. https://doi.org/10.1177/1941738120936673

Khalid, A. J., Ian Harris, S., Michael, L., Joseph, H., & Qu, X. (2015). Effects of neuromuscular fatigue on perceptual-cognitive skills between genders in the contribution to the knee joint loading during side-stepping tasks. *Journal of Sports Sciences*, *33*(13), 1322–1331. https://doi.org/10.1080/02640414.2014.990485

Kyritsis, P., Witvrouw, E., & Landreau, P. (2015). Return to the field for football (soccer) after anterior cruciate ligament reconstruction: Guidelines. In *Sports Injuries: Prevention, Diagnosis, Treatment and Rehabilitation, Second Edition* (pp. 1503–1515). https://doi.org/10.1007/10.1007/978-3-642-36569-0_121

LaBella, C. R., Hennrikus, W., Hewett, T. E., Brenner, J. S., Brooks, A., Demorest, R. A., Halstead, M. E., Weiss Kelly, A. K., Koutures, C. G., LaBotz, M., Loud, K. J., Martin, S. S., Moffatt, K. A., Benjamin, H. J., Cappetta, C. T., McCambridge, T., Gregory, A. J. M., Kluchurosky, L. K., Philpot, J. F., … Alexander, S. N. (2014). Anterior cruciate ligament injuries: Diagnosis, treatment, and prevention. *Pediatrics*, *133*(5), e1437–e1450. https://doi.org/10.1542/peds.2014-0623

Lin, C. W., Huang, C. F., Wang, J. S., Fu, L. L., & Mao, T. Y. (2020). Detection of ventilatory thresholds using near-infrared spectroscopy with a polynomial regression model. *Saudi Journal of Biological Sciences*, *27*(6), 1637–1642.

Marcos, M. A., Koulla, P. M., & Anthos, Z. I. (2018). Preseason Maximal Aerobic Power in Professional Soccer Players Among Different Divisions. *The Journal of Strength & Conditioning Research*, *32*(2). https://journals.lww.com/nsca-jscr/fulltext/2018/02000/preseason_maximal_aerobic_power_in_professional.8.aspx

Midgley, A. W., McNaughton, L. R., Polman, R., & Marchant, D. (2007). Criteria for Determination of Maximal Oxygen Uptake. *Sports Medicine*, *37*(12), 1019–1028. https://doi.org/10.2165/00007256-200737120-00002

Modric, T., Versic, S., & Sekulic, D. (2020). Aerobic fitness and game performance indicators in professional football players; playing position specifics and associations. *Heliyon*, *6*(11), e05427. https://doi.org/https://doi.org/10.1016/j.heliyon.2020.e05427

Neto, V. H. G., Neves, L. N. S., Kalva-Filho, C. A., Schwingel, P. A., Leite, R. D., & Carletti, L. (2022). Cardiopulmonary Exercise Testing with Elastic Resistance: A New Reproducible Proposal for Determination of Ventilatory Thresholds and Maximum Oxygen Consumption. *Journal of Sports Science and Medicine*, *21*(3), 426–434. https://doi.org/10.52082/jssm.2022.426

Poulios, A., Fatouros, I. G., Mohr, M., Draganidis, D., Deli, C. K., Papanikolaou, K., Sovatzidis, A., Nakopoulou, T., Ermidis, G., Tzatzakis, T., Laschou, V. C., Georgakouli, K., Koulouris, A., Tsimeas, P., Chatzinikolaou, A., Karagounis, L. G., Batsilas, D., Krustrup, P., & Jamurtas, A. Z. (2018). Post-Game High Protein Intake May Improve Recovery of Football-Specific Performance during a Congested Game Fixture: Results from the PRO-FOOTBALL Study. *Nutrients*, *10*(4). https://doi.org/10.3390/nu10040494

Roa, M. S., Galeano, E. E., Luis, C. :, Medina, S., Cohen, D. D., Carlos, J., Noguera, Q., Trujillo, J. A., Pineda, M. S., Chaparro, I. A., Herrera, R., Salamanca, A., & Medina, A. (2015). *Lineamientos de Política Pública en Ciencias del Deporte en Medicina* (1st ed.). Partner Mercadeo y Medios Gráficos S.A.S.

Robles Pino, A., Pairazamán Guevara, R., & Pereyra Elías, R. (2019). Anthropometric characteristics and aerobic capacity among players of the U-22 Peruvian Football Team, 2015. *Nutricion Clinica y Dietetica Hospitalaria*, *39*(3), 104–108. https://doi.org/10.12873/393robles

Sahlin, K. (2014). Muscle Energetics During Explosive Activities and Potential Effects of Nutrition and Training. *Sports Medicine*, *44*, 167–173. https://doi.org/10.1007/s40279-014-0256-9

Santos, E. L., & Giannella-Neto, A. (2004). Comparison of computerized methods for detecting the ventilatory thresholds. *European Journal of Applied Physiology*, *93*(3), 315–324. https://doi.org/10.1007/s00421-004-1166-6

Slimani, M., & Nikolaidis, P. T. (2019). Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. *J Sports Med Phys Fitness*, *59*(1), 141–163. https://doi.org/doi:10.23736/S0022-4707.17.07950-6

Teixeira, A. S., Guglielmo, L. G. A., Fernandes-da-Silva, J., Konarski, J. M., Costa, D., Duarte, J. P., Conde, J., Valente-dos-Santos, J., Coelho-e-Silva, M. J., & Malina, R. M. (2018). Skeletal maturity and oxygen uptake in youth soccer controlling for concurrent size descriptors. *PLOS ONE*, *13*(10), e0205976. https://doi.org/10.1371/journal.pone.0205976

Tonnessen, E., Hem, E., Leirstein, S., Haugen, T., & Seiler, S. (2013). Maximal Aerobic Power Characteristics of Male Professional Soccer Players, 1989–2012. *International Journal of Sports Physiology and Performance*, *8*(3), 323–329. https://doi.org/10.1123/ijspp.8.3.323

Waldén, M., Hägglund, M., Magnusson, H., & Ekstrand, J. (2016). ACL injuries in men's professional football: A 15-year prospective study on time trends and return-to-play rates reveals only 65% of players still play at the top level 3 years after ACL rupture. *British Journal of Sports Medicine*, *50*(12), 744–750. https://doi.org/10.1136/bjsports-2015-095952

Watson, A., Brindle, J., Brickson, S., Allee, T., & Sanfilippo, J. (2017). Preseason Aerobic Capacity Is an Independent Predictor of In-Season Injury in Collegiate Soccer Players. *Clinical Journal of Sport Medicine*, *27*(3). https://journals.lww.com/cjsportsmed/fulltext/2017/05000/preseason_aerobic_capacity_is_an_independent.11.aspx

Zaffagnini, S., Grassi, A., Muccioli, G. M. M., Tsapralis, K., Ricci, M., Bragonzoni, L., Della Villa, S., & Marcacci, M. (2014). Return to sport after anterior cruciate ligament reconstruction in professional soccer players. *Knee*, *21*(3), 731–735. https://doi.org/10.1016/j.knee.2014.02.005

Cite this article as: Buitrago-Espitia, J. E., Rincón-Ramírez, J. A., del Pilar Prieto Mondragón, L., Rodríguez Buitrago, J. A., Sánchez Rodríguez, D. A., Ochoa Reyes, N. D., Ordoñez Saavedra, N., Sierra Arévalo, W. A., & Suárez Forero, C. A. (2025). Correlation Study between Oxygen Consumption and Body Composition in Professional Soccer Players and Non-Athlete Populations with and without Anterior Cruciate Ligament Rupture. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 59–72. https://doi.org/10.18276/cej.2025.3-05

Central European Journal of Sport Sciences and Medicine | Vol. 51, No. 3/2025: 73–86
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2025.3-06

EATING DISORDERS IN SPORT: A NARRATIVE REVIEW OF STUDIES ON EATING DISORDERS AMONG ATHLETES

Laura Kaliczyńska

University of Szczecin, Doctoral School of the University of Szczecin, Poland
ORCID: 0009-0000-9836-1434 | e-mail: laura.kaliczynska@phd.usz.edu.pl

Abstract Eating disorders in sports represent a significant health issue that has drawn the attention of researchers worldwide. Selected studies suggest that disordered eating behaviors among athletes occur more frequently than in non-athletic individuals (Ghazzawi et al., 2024; Jaššová & Dostal, 2022; Torstveit et al., 2008). It is believed that such behaviors may result, in part, from the pursuit of an ideal body image specific to the sport, as well as from attempts to alleviate dissatisfaction with one's appearance, shaped by the aesthetic demands and expectations concerning the physical presentation of the athlete (Torstveit et al., 2008). Despite numerous studies addressing this phenomenon, research findings remain inconclusive, and knowledge in this area requires further exploration. The aim of this narrative review is to present the current state of knowledge on eating disorders in sports, with a particular focus on risk factors for their development, negative health consequences, and potential support methods for those affected. Considering that eating disorders in sports can lead to serious health consequences, expanding knowledge in this area and implementing appropriate preventive measures may contribute to reducing morbidity and improving the well-being of athletes.

Key words: eating disorders, sport, risk factors, athlete health, prevention

Introduction

"Feeding and eating disorders are characterized by a persistent disruption in eating behavior, accompanied by abnormal behaviors related to nutrition. As a result, this leads to changes in the composition and absorption of food, which in turn causes a significant deterioration in physical health and psychosocial functioning" (APA, 2018, cited in Gałecki et al., 2018, p. 399). These serious and often chronic mental disorders are believed to arise from a complex combination of psychological, biological, social, and cultural factors (Culbert et al., 2015), with their development typically beginning during adolescence or early adulthood (Giel et al., 2016), a period that generally corresponds to the professional sports activity phase (Szewczyk et al., 2024). In recent years, there has been a significant increase in interest in eating disorders among athletes, as studies have shown that this issue occurs more frequently in this group than in non-athletes (Ghazzawi et al., 2024; Eichstadt et al., 2020). In the literature, the prevalence of eating disorders among adult athletes ranges from 0–19% for men and 4–45% for women (Magee et al., 2023), whereas in the general population of young adults, it is 0.6–2.4% for men and 5.5–17.9% for women (Silen & Keski-Rahkonen, 2022). Although research results in this area are often inconsistent due to, among other things, methodological differences and the heterogeneity of the studied groups, it is believed that the actual scale of the problem in sports may be even higher. This underestimation may be related to the hidden nature of the disorders and athletes' reluctance to report them, stemming from the belief in the beneficial impact of dietary restrictions and excessive physical exercise on athletic performance (Thompson & Sherman, 2010; Wells et al., 2020).

Given the high risk of morbidity in sports and the greater challenges in detecting eating disorders compared to the general population of non-athletes, the following review presents available research on this topic. The aim was to identify findings that may be useful in the detection and treatment of eating disorders among athletes.

In this article, the term "disordered eating" is used to refer to persistent eating patterns that are not necessarily indicative of a diagnosable mental health disorder but are considered by specialists as behaviors that increase the risk of developing full-blown eating disorders. These behaviors may involve reduced or excessive food intake, restricted food choices, feelings of loss of control, physical discomfort, or other negative emotions such as guilt or shame (Ghazzawi et al., 2024). It is important to note that disordered eating patterns may be observed in individuals with eating disorders, but not everyone who exhibits such behaviors will meet the criteria for full-blown eating disorders (El Ghoch et al., 2013; Krentz & Warschburger, 2013).

Material and Methods

A narrative literature review was conducted on eating disorders in sport, covering publications from 1993 onwards- the year in which Sundgot-Borgen's seminal study demonstrated a higher prevalence of eating disorders among female athletes compared to non-athletic women.

The literature search was carried out between December 2024 and February 2025 using electronic databases including EBSCO, Google Scholar, Scopus, and PubMed. In addition, relevant scholarly books were reviewed. To identify appropriate publications, the following keywords were used: *eating disorders in sport*, *disordered eating among athletes*, and *dysfunctional eating among athletes*. Publications were screened based on titles and abstracts. Only peer-reviewed journal articles and recognized academic books addressing eating disorders- both general and sport-specific-were included for further analysis. Abstracts, theses, methodological papers, and conference proceedings were excluded.

Ultimately, 66 sources meeting the inclusion criteria were selected for this review. The structure of the review is organized around five key thematic areas: 1. State of knowledge, 2. Types of eating disorders, 3. Etiology of eating disorders in sport, 4. Consequences of eating disorders in sport, 5. Prevention and treatment of eating disorders in sport.

State of knowledge

Eating Disorders in Sports

Research indicates that the prevalence of eating disorders is higher among athletes than in the general population, particularly in sports that promote low body weight and a lean physique (Byrne & McLean, 2002; Hausenblas & Carron, 1999; Sundgot-Borgen & Tortsveit, 2004). The literature distinguishes between "lean" sports, where low body weight is required (e.g., gymnastics, long-distance running), and "non-lean" sports, where body weight is not a key factor (e.g., basketball, table tennis) (Martinsen et al., 2010). Rousselet et al. (2017) confirmed that athletes participating in the first group of sports are more likely to display unhealthy eating habits. In the study by Ghazzawi et al. (2024), the highest percentage of eating disorders was found in gymnastics (41.5%), and the lowest in endurance sports (15.4%). Chatterton and Petrie (2013) and Krentz and Warschburger (2013) also identified aesthetic sports, such as gymnastics and figure skating, as being associated with higher rates of eating disorders. Mancine et al. (2020), who compared different sports disciplines, confirmed that the highest likelihood of developing eating disorders occurred in sports requiring low body weight, weight-class sports, and those in which an athlete's appearance is subject to evaluation. Rosendahl et al. (2009), on the other hand, differentiated by gender, showing that the highest risk of developing eating disorders in men was found in anti-gravity sports (42%), while in women, it was found in aesthetic sports (42%).

Numerous studies also confirm the link between the level of competition and the risk of eating disorders. Sundgot-Borgen (1994) demonstrated that professional athletes are more prone to these issues than amateurs. Goldfield & Woodside (2009) observed that women who train recreationally are less likely to exhibit symptoms of eating disorders than professional athletes, who more often follow restrictive diets, engage in excessive exercise, and become obsessed with their body weight, which may result from the pressure of competition and expectations from the sports environment. Meanwhile, Engel et al. (2003) and Berry and Howe (2000) suggested that a significant risk factor in this group is the comments made by coaches and the pressure to maintain a specific physique.

Table 1. Selected studies on the prevalence of eating disorders among athletes

Type of Sport	Key Findings	Authors (Year)
Various	Higher prevalence of eating disorders compared to the general population	Byrne & McLean (2002)
Lean vs. non-lean	"Lean" sports are associated with higher risk of eating disorders	Hausenblas & Carron (1999)
Various	Higher prevalence among elite athletes, particularly females	Sundgot-Borgen & Tortsveit (2004)
Lean	Athletes in lean sports are more likely to exhibit disordered eating behaviors	Rousselet et al. (2017)
Aesthetic, Endurance	Highest prevalence in gymnastics (41.5%), lowest in endurance sports (15.4%)	Ghazzawi et al. (2024)
Aesthetic	Elevated risk in gymnastics and figure skating	Chatterton & Petrie (2013)
Aesthetic	Aesthetic sports pose the highest risk	Krentz & Warschburger (2013)
Lean, Weight-class, Aesthetic	Greatest risk in sports emphasizing thinness and appearance evaluation	Mancine et al. (2020)
Antigravitational, Aesthetic	Men: highest risk in antigravitational sports (42%); Women: aesthetic sports (42%)	Rosendahl et al. (2009)
Various	Elite athletes more vulnerable than amateurs	Sundgot-Borgen (1994)
Various	Female professionals more likely to exhibit ED symptoms and adhere to restrictive diets	Goldfield (2009)

*ED – eating disorders; lean – disciplines requiring low body weight (e.g. gymnastics), non-lean – disciplines without such a requirement (e.g. table tennis). *

Types of Eating Disorders

The most commonly diagnosed forms of eating disorders according to DSM-V are anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED) (APA, 2018, cited in Gałecki, 2018). Anorexia is characterized by a significant restriction in energy intake relative to the body's needs and an intense fear of gaining weight. Bulimia involves recurrent episodes of binge eating, followed by inappropriate compensatory behaviors aimed at preventing weight gain (e.g., self-induced vomiting, abuse of laxatives, diuretics, excessive physical exercise). Binge eating disorder is characterized by the consumption of large amounts of food in a short period and a sense of loss of control during the episode. Binge eating is associated with eating faster than most people, eating until feeling uncomfortably full, consuming large amounts of food even when not hungry, and experiencing feelings of disgust with oneself, depression, or an intensified sense of guilt after the episode (Brytek-Matera, 2021).

Although the characteristics of eating disorders outlined above are consistent with DSM-V, it should be noted that improper eating behaviors in sports do not always meet the criteria for full-blown clinical eating disorders. When discussing this issue, it is important not to overlook unclassified, yet pathological, eating patterns that may act as potential precursors to full-blown eating disorders (Monthuy-Blanc et al., 2020, 2022a, cited in Daubresse et al., 2024). The literature introduces the concept of DEAB (dysfunctional eating attitudes and behaviors), which refers to dysfunctional eating attitudes and behaviors that form a continuum between healthy eating and the diagnoses of eating disorders described in the classification of mental disorders. These behaviors and attitudes include eating behaviors such as intuitive eating, emotional eating, restrictive dieting, or episodes of binge eating (Monthuy-Blanc et al., 2022b, cited in Daubresse et al., 2024). DEAB can also be associated with purging behaviors, internalization of the ideal slim physique, food control, and fluctuations in body weight, particularly during periods of sports competition (Homan, 2010). It has been found that as many as 51.6% of athletes at the national level report using DEAB to lose weight (Chatterton & Petrie, 2013). Similar to classified eating disorders, the prevalence of DEAB varies depending on the sport and gender (Petrie, 2020). Individual sports are more strongly predisposed to DEAB than team sports, with endurance sports (e.g., running, triathlon, etc.) being particularly associated with these behaviors (Nattiv et al., 2007; Sundgot-Borgen & Torstveit, 2004).

Another noteworthy and sport-specific form of unclassified eating disorder is known as anorexia athletica (AA), which is a form of anorexia nervosa occurring in physically active individuals. It should be emphasized that this is an eating disorder that is not clinically diagnosed (Nielson et al. 2013) and is not formally recognized as a nosological diagnosis. It is defined as a state of restricted energy intake and reduced body mass while maintaining a high level of physical activity (Kristjansdottir, 2019). A characteristic feature is that individuals do not restrict calories as drastically as in AN but have a carefully calculated energy requirement, thus consuming and training to maintain a constant calorie deficit. This is particularly dangerous because such an individual may appear to be eating properly. Fear of gaining weight is a strong motivator for individuals with AA, although it is often unjustified, as these individuals usually weigh less than the norms established for their height and age. Literature confirms that the most vulnerable groups to these patterns of behavior are athletes in disciplines such as running, gymnastics, and figure skating (Bolles et al., 2005). In these sports, low weight may enhance athletic performance, which individuals with AA relentlessly pursue, often dedicating most of their time to this goal (Nielson, 2013). It is also important to note that weight reduction is motivated by the desire to improve athletic performance, rather than by the typical concerns with body weight or external appearance seen in anorexia nervosa (Sudi et al., 2004). Sundgot-Borgen (1993) assessed the prevalence of AA at 8%, while in later works by the author (Sundgot-Borgen & Tortsveit, 2004), the prevalence was found to be 4% for women and 1% for men in professional sports.

Another significant term to mention when discussing unclassified eating disorders in sports is "orthorexia." The term orthorexia nervosa first appeared in the late 1990s, and it wasn't until 2004 that the first article described orthorexia as a "maniacal obsession" with healthy eating (Donini, 2004). Currently, orthorexia is not classified in DSM-5 or ICD-11, and there is still ongoing debate about whether it should be considered a distinct mental disorder (McComb & Mills, 2019; Meule & Voderholzer, 2021). Although many authors have developed diagnostic criteria for orthorexia (Cena et al., 2019), it was not until the article by Donini et al. (2022) that the first definition of orthorexia, supported by specialists from around the world, was presented. In this definition, orthorexia is described as a strong engagement of the individual in eating-related behaviors and the imposition of rigid rules, which remain under strict control and are associated with spending excessive time planning, acquiring, preparing, and/or consuming food. Unlike other well-known eating disorders, orthorexia does not focus on the quantity of food consumed but rather its quality (Dunn & Bratman, 2016). Individuals suffering from this disorder experience emotional discomfort when confronted with food they consider unhealthy, difficulties with concentration because thoughts about healthy eating almost entirely occupy their minds, and feelings of guilt when they cannot consume a meal that meets their restrictive requirements (Donini et al., 2022). The selective eating patterns characteristic of orthorexic individuals can contribute to nutritional deficiencies, such as underweight, anemia, or hormonal imbalances (Donini et al., 2022; Bundros et al., 2016). This disorder can also have a significant impact on an individual's personal and social functioning, as it involves dedicating most of their time to meeting the requirements of their diet. Research indicates that higher rates of orthorexia are found among individuals who engage in sports for more than 150 minutes per week compared to those who engage in sports less frequently or not at all. Additionally, a higher probability of orthorexic behaviors has been confirmed among individuals participating in endurance sports (over 150 minutes/week) compared to those in other sports (Bert et al., 2019). Oberle's et al. (2017) study showed that the tendency to exhibit such behaviors is linked to the intensity of aerobic exercises performed, exercise addiction, and motivation for exercise.

Etiology of Eating Disorders in Sports

Existing research indicates that eating disorders have a multifactorial nature, highlighting both biological and psychosocial factors. In addition to the primary risk factor, which is the specificity of the sport being practiced (discussed earlier in the article), gender is often cited as an additional factor. While most studies confirm that women are more prone to displaying disordered eating behaviors (Engel et al., 2003), it should be emphasized that this problem also affects men. Ahlich et al. (2018) estimate that they may constitute up to 25% of athletes struggling with disordered eating. Dakanalis et al. (2016) in their study found that binge eating (7.9%) and excessive physical exercise (4.4%) are the most common behaviors in a male student group. Therefore, despite women predominating in terms of eating-related problems, men should not be excluded from the risk group for developing such disorders.

Traditional models of the development of eating disorders in sports emphasize the influence of environmental factors, such as societal pressure regarding appearance, diet-related pressures, and the demand for body modifications through training (Garner, Garfinkel, 1980; Striegel-Moore, Silberstein, Rodin, 1986 as cited in Łuszczyńska, 2011). A more recent approach, the model proposed by Petrie and Greenleaf (2007), in addition to the environmental context, focuses on subjective beliefs, emotions, and cognitive patterns of athletes, which may increase susceptibility to the development of disordered eating. In addition to environmental pressures regarding a slim figure, they point to idealization of low body weight, dissatisfaction with one's appearance, negative emotions, a restrictive approach to eating, and the influence of peers and family on eating patterns. This model is particularly significant as it is based on solid empirical foundations, indicating mechanisms that may reinforce the risk of these disorders and specifies situations in which the effect of a given risk factor is especially strong (Petrie & Greenleaf, 2007). A different perspective, which seems interesting, is the approach of Nattiv et al. (2007), which distinguishes three groups of risk factors: predispositional, triggering, and maintaining. The first category includes biological, psychological, and socio-cultural factors that increase an individual's susceptibility to developing disorders, such as genetic predispositions, body dissatisfaction, low self-esteem, or personality traits (e.g., perfectionism). Triggering factors include negative comments about appearance and traumatic experiences (Stice & Shaw, 2002). Maintaining factors are attributed to, among others, acceptance by the surrounding environment, physiological consequences of hunger, or initial positive effects of dietary restrictions (Nattiv et al., 2007). The literature also mentions sport-specific risk factors that include a range of important elements that may affect athletes' health. These include frequent changes in body weight, environmental pressures for weight loss, frequent dieting, starting specialized sports training at a young age, traumatic experiences such as injuries, overtraining, the desire to gain admiration, coaching behaviors, and specific sport rules (Bratland-Sanda & Sundgot-Borgen, 2012; Smolak et al.,2000; Sundgot-Borgen, 1994). Body weight regulations in sports practiced at a professional level are especially relevant in disciplines where body mass is controlled during competition. These include weight-class sports, such as boxing, judo, or other combat sports. In these disciplines, extreme methods of rapid weight loss may be employed in the period immediately preceding the pre-competition weigh-in. Athletes in disciplines where low body weight can enhance performance and those in sports where physical appearance is evaluated (such as gymnastics or aesthetic sports) may also be exposed to pressure from the environment to lose weight (Byrne & McLean, 2002; Hausenblas & Carron, 1999). In the case of early engagement in sports training, there is a risk of mismatching the choice of sport to the athlete's body type, which may lead to later difficulties associated with the impact of changes during the maturation process on sports performance (Sundgot-Borgen, 1994). Another issue is that some traits regarded as desirable in sports, such as perfectionism, a tendency to conform, and intense engagement in training, may simultaneously contribute to the development of eating disorders (Thompson & Sherman, 1999). Athletes often exhibit obsessive-compulsive striving for achievement, which increases their susceptibility to unhealthy eating habits. A risk factor can also be traumatic experiences, especially injuries, which often lead to exclusion from competition and, consequently, uncontrolled weight gain and eating problems (Currie, 2010). Coaching styles play a key role in many behaviors exhibited by athletes. A supportive attitude may offer protection, while a focus on results and athletes' weight may be particularly predispositional to the development of eating disorders, amplifying their fear of weight gain and triggering disorders in this area (Bratland-Sanda & Sundgot-Borgen, 2012).

Table 2. Risk factors for the development of eating disorders in sport

Type of Risk Factor	Description	References
Gender	Women are more susceptible, although men are also affected	Engel et al. (2003); Ahlich et al. (2018); Dakanalis et al. (2016)
Environmental Factors	Societal pressure regarding appearance, dieting pressures, physique-related expectations	Garner & Garfinkel (1980); Striegel-Moore et al. (1986, as cited in Łuszczyńska, 2011)
Cognitive and Emotional Factors	Body dissatisfaction, idealization of thinness, negative affect	Petrie & Greenleaf (2007)
Predisposing Factors	Genetics, low self-esteem, perfectionism, body dissatisfaction	Nattiv et al. (2007)
Triggering Factors	Trauma, negative appearance-related comments	Stice (2002); Nativ et al. (2007)
Maintaining Factors	Environmental reinforcement, physiological effects of starvation, perceived benefits of dietary restraint	Nattiv et al. (2007)
Sport-Specific Factors	Early training onset, frequent weight fluctuations, recurrent dieting, traumatic experiences (e.g., injuries), coach behaviors, sport rules, weight-loss pressure from surroundings	Bratland-Sanda & Sundgot-Borgen (2012); Smolak et al. (2000); Sundgot-Borgen (1994)

Sport Discipline Characteristics	Appearance-based evaluation, weight-class sports (e.g., boxing, judo), performance advantages from low body weight	Byrne & McLean (2002); Hausenblas & Carron (1999)
Personality Traits	Perfectionism, compliance, obsessive-compulsive striving for achievement	Thompson & Sherman (1999)
Traumatic Experiences	Especially injuries associated with weight gain	Currie (2010)
Coaching Styles	Supportive coaching – protective; weight-focused coaching – risky	Bratland-Sanda & Sundgot-Borgen (2012)

Consequences of Eating Disorders in Sport

Given the fact that certain categories of athletes may be more vulnerable to disordered eating behaviors than others (Mancine et al., 2020), which in turn can lead to nutritional imbalances associated with numerous physical and psychological health consequences, it is important to examine the effects they may have on the described group. It has been demonstrated that athletes reporting eating disorders exhibit higher levels of depression and anxiety compared to athletes who do not experience such problems (Landkammer et al., 2019). Among this group, common difficulties also include effects directly caused by insufficient energy intake. One of the terms used in the literature to describe such conditions is LEA (Low Energy Availability), which refers to a state where, due to insufficient energy intake, the athlete's body is unable to meet the demands placed on it by physical activity (Õnnik et al., 2022). This can arise when an athlete consumes insufficient energy from food or expends excessive amounts during training. The main causes of LEA are generally categorized as obsessive (eating disorders or clinical diagnoses of eating disorders), unintentional (a health issue as a side effect of high energy expenditure during exercise), or intentional (efforts to modify body weight or composition) (Burke, 2021 cited in Lee, 2024). LEA is often considered a precursor to disorders such as RED-S (Relative Energy Deficiency in Sport) or MAT (Male Athlete Triad), and it is most frequently encountered in sports characterized by high intensity, frequency, duration, or volume, as well as those that emphasize low body weight and/or low body fat percentage (e.g., cycling, running, triathlon, gymnastics, tennis, rowing) (Lee, 2024).

To illustrate the multitude of negative effects caused by energy deficiency in sports, some of their characteristics are presented. In the literature, the term "female athlete triad" is used, which refers to a syndrome involving three interrelated disorders frequently found among female athletes. These include disordered eating or at least a significant restriction in caloric intake, menstrual disturbances or absence of menstruation, and decreased bone mineral density, i.e., osteoporosis (Mancine et al., 2020). The above-mentioned conditions can lead to serious health issues among female athletes, such as bone fractures, hormonal disorders, and cardiovascular problems. Over the past few years, the prevalence of this issue among female athletes has ranged from 1.3% to 23%, with as many as 78% of female athletes showing at least one of the three components of the triad (Petrović, 2020). This disorder is particularly prevalent in disciplines where leanness or low body weight is emphasized, such as long-distance running, gymnastics, or track and field.

A similar term exists in the literature for male athletes, referred to as MAT (Male Athlete Triad), which can be interpreted as the triad of male athletes. This syndrome consists of three interconnected disorders observed in male athletes: low energy availability (LEA), impaired bone health that may lead to osteopenia, osteoporosis, or bone injuries, and dysfunction of the hypothalamic-pituitary-gonadal (HPG) axis, resulting in conditions such as hypogonadotropic hypogonadism, which may lead to oligospermia (low sperm count) or decreased libido (Nattiv et al., 2021). The risk of MAT, like in females, is particularly high among athletes participating in disciplines that require low body mass, such as long-distance running or cycling (Nattiv et al., 2021).

Another concept describing the health consequences of disordered eating in athletes is “Relative Energy Deficiency in Sport” (RED-S), which encompasses the same three disorders identified in the female athlete triad but also includes other health consequences resulting from LEA in athletes (Mountjoy et al., 2018). The term RED-S refers to a condition in which an athlete does not intake sufficient energy relative to their body’s needs, leading to a range of negative health and performance-related outcomes. Unlike the female or male athlete triads, RED-S considers a broader spectrum of the consequences of low energy availability, covering not only aspects related to the bone and hormonal systems but also to other systems in the body, including the immune, digestive, cardiovascular, and metabolic systems. RED-S offers a more holistic approach to the problem of energy deficiency in sport, considering its complex consequences for the health and performance of athletes of both sexes.

Table 3. Health effects of disordered eating among athletes

Term/Concept	Description	Target Group	Main Health Consequences	References
LEA (Low Energy Availability)	Condition of insufficient energy availability relative to physiological needs	Both male and female athletes	Hormonal disturbances, impaired recovery, possible HPG axis dysregulation	Õnnik et al. (2022); Burke (2021), cited in: Lee, 2024)
RED-S (Relative Energy Deficiency in Sport)	A syndrome encompassing multiple consequences of energy deficiency	Both male and female athletes	Endocrine, skeletal, immune, and cardiovascular impairments	Mountjoy et al. (2018)
Female Athlete Triad	Triad of disordered eating/low energy intake, amenorrhea, and osteoporosis	Female athletes	Menstrual dysfunction, osteoporosis, fractures, hormonal issues	Mancine et al. (2020); Petrović (2020)
Male Athlete Triad (MAT)	Male counterpart of the Female Athlete Triad: LEA, poor bone health, and HPG axis disturbances	Male athletes	Osteopenia, osteoporosis, hypogonadism, reduced libido, oligospermia	Nattiv et al. (2021)
Psychological Issues	Increased incidence of depression and anxiety in athletes with disordered eating	Both male and female athletes	Depression, anxiety	Sundgot-Borgen et al. (2016)

Prevention and Treatment of Eating Disorders in Sport

Prevention and treatment of eating disorders in sport are largely based on methods used in the general population. However, in the case of athletes, a broader, interdisciplinary approach is necessary, involving not only the athlete but also their immediate environment. This process often includes the involvement of family members, coaches, dietitians, doctors, sports psychologists, and other specialists supporting the athlete’s physical and mental preparation. A key element of prevention is education for both athletes and their surroundings regarding eating disorders. Educational programs focus on identifying and learning to recognize risk factors, discussing the health consequences, and eliminating myths about the relationship between body weight and sports performance (Coelho et al., 2014). An important aspect of prevention is also the early detection of nutritional issues and the implementation of interventions that prevent further development of the problem. Due to the specificity of sport, it is crucial to assess whether the observed behaviors are temporary (e.g., resulting from a competition preparation phase and are controlled) or represent a persistent, unhealthy pattern leading to the development of eating disorders (Ljungqvist et al., 2009).

Regular screening, conducted as part of mandatory medical examinations before the start of the season, plays a vital role in identifying athletes at particular risk for the development of these disorders. Diagnostic procedures include questions about eating habits, binge eating episodes, the use of purging methods, the presence of eating disorders in the family, body image perception, menstrual cycle, and physical activity levels (Rumball & Lebrun, 2004; Coelho et al., 2014). Given the risk of concealing important information by those being examined, self-report tools are also used, which may help detect abnormal eating patterns early. Their anonymous nature may encourage greater openness in revealing problematic behaviors (Hagmar et al., 2008). However, it should be emphasized that such diagnostic methods should always be supplemented with a clinical interview and conversation, allowing for a comprehensive assessment of the situation.

A sport-specific form of preventive measures could involve changes in regulations regarding body weight control in disciplines that require weight limitations. The elimination of extreme weight loss methods, such as drastic calorie restriction or intense dehydration, can significantly reduce the risk of developing eating disorders in this group of athletes (Coelho et al., 2014). Special attention should be given to monitoring athletes' eating behaviors during recovery periods from injuries and after returning to regular training. During forced breaks in physical activity, some athletes may resort to unhealthy methods of body weight control, attempting to prevent weight gain resulting from reduced movement.

Treatment of eating disorders in athletes should also be interdisciplinary and involve collaboration among a team of specialists. A crucial role in the therapeutic process is played by psychotherapy, particularly cognitive-behavioral therapy (CBT), which is considered one of the most effective treatment methods. Among the approaches used, enhanced cognitive-behavioral therapy (CBT-E), Maudsley therapy (MAN-TRA), Specialist Supportive Clinical Management (SSCM), and psychodynamic therapy (FPT) are distinguished (Brytek-Matera, 2021). The therapeutic process in an outpatient setting usually lasts around eight months or longer and involves individual cooperation between the patient and the therapist. Its primary goals are to restore physical health, gradually normalize eating patterns, and stabilize body weight. Cooperation between coaches and the training staff with therapists plays a key role in creating an environment conducive to the athlete's recovery. An important element of therapy is also the gradual and controlled return to physical activity, which minimizes the risk of relapse into destructive behaviors, as well as raising the awareness of those around the coach regarding important behavioral signals in the athlete that need to be addressed. Additionally, a properly tailored dietary intervention, adjusted to the individual needs of the athlete, can provide crucial support in the recovery process.

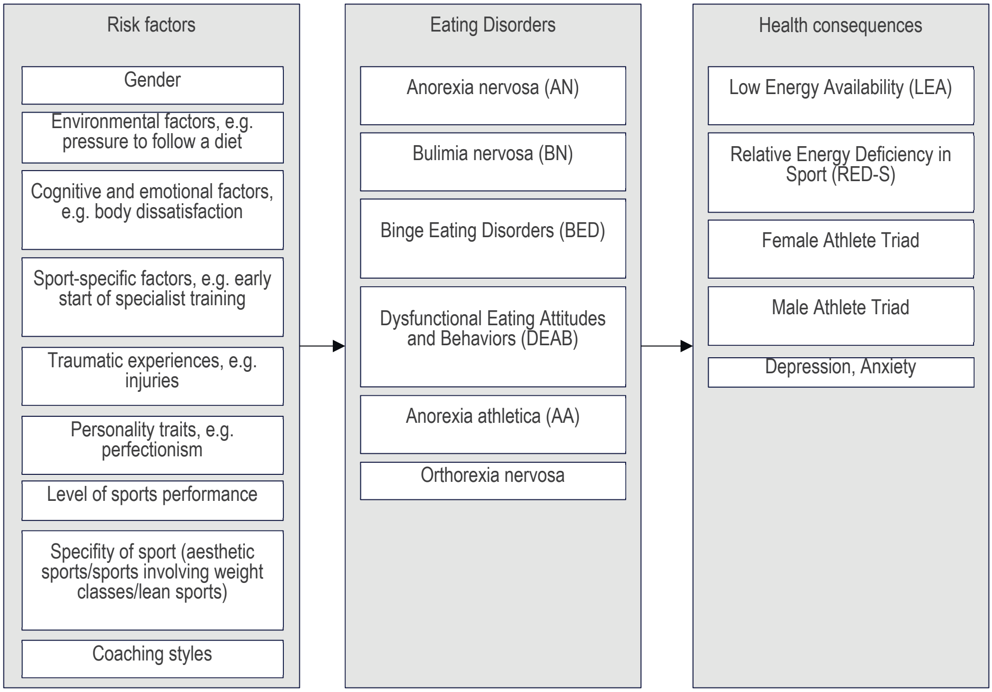


Figure 1. Conceptual model of the development and consequences of eating disorders in athletes

Summary

This paper presents a narrative review of research on eating disorders among athletes. It is important to emphasize that although there are specific diagnostic criteria, relatively few studies focus on describing eating disorders as clinical conditions. It should be noted that a full diagnosis of eating disorders requires a comprehensive clinical assessment, typically conducted by psychiatrists. For this reason, this paper primarily presents quantitative research findings that assess the presence of unhealthy eating habits and patterns that may promote the development of full-blown disorders, rather than clinical descriptions of the disorders themselves.

The analysis identifies risk factors and the relationships between specific sports disciplines and the propensity for eating disorders. However, it should be noted that the entire athlete population, regardless of the sport or skill level, is highly vulnerable to such problems. Research by Thompson and Sherman (2010) confirms that even among athletes participating in sports where body weight and appearance are not key, over 50% engage in unhealthy weight control practices, such as inducing vomiting or restricting calorie intake. Therefore, prevention efforts should not only target athletes in aesthetic or weight-class-dependent sports but also those who theoretically do not face pressure related to body mass or appearance (Selby et al., 2011).

Further research on eating disorders in sport is needed, especially considering the methodological variability used in previous studies (e.g., different measurement tools, sample sizes, age, gender, and cultural contexts). Research results in this area are inconclusive—some suggest that athletes are more susceptible to eating disorders than non-athletes, while others indicate no significant differences between the groups (Chapa et al., 2022). Therefore, there is a need for studies conducted on a representative sample of athletes (both professionals and amateurs) from a wide range of disciplines, using a uniform research procedure.

Due to limited availability of research, this paper did not address athletes in disciplines where a higher body mass is beneficial for achieving better results (e.g., sumo, weightlifting). Additionally, due to the insufficient number of available publications, the frequency of specific eating disorders in various athlete groups has not been thoroughly analyzed, nor was the issue in amateur sports addressed. In the context of modern culture, which promotes a healthy athletic physique (slim for women and muscular for men) it can be hypothesized that the risk of eating disorders among both professional and amateur athletes is similar. However, verification of this hypothesis requires further empirical studies.

It is crucial to note that the presented description of eating disorders aims to highlight the issue and point out possible behaviors, emotions, and experiences of individuals struggling with these disorders. It is important to remember that the course of these disorders may be atypical, and some symptoms may fit into multiple diagnostic categories simultaneously. Therefore, particular caution should be exercised when interpreting the results of quantitative studies. The diagnosis of eating disorders should rely on in-depth analysis, including clinical interviews and other qualitative methods conducted by qualified specialists. This article aims to expand public knowledge about these disorders, which can contribute to more effective prevention and early detection of the problem.

Conclusion

In conclusion, eating disorders among athletes represent a significant and current issue that can have serious consequences for both the physical and mental health of athletes. Due to diagnostic challenges and the potential negative effects of these disorders, widespread preventive actions are necessary. A key role in this regard is played by doctors and sports psychologists, who should conduct educational initiatives not only for athletes but also for coaches, training staff, and athletes' families. Early identification of eating disorder symptoms and appropriate interventions can contribute to improving athlete's health and well-being and increase their chances for a long and successful sports career.

References

American Psychiatric Association (APA). (2018). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5).* American Psychiatric Publishing, ISBN: 978-0-8904-555-8.

Ahlich, E., Choquette, E. M., & Rancourt, D. (2018). Body talk, athletic identity, and eating disorder symptoms in men. *Psychol Men Masculin*, *20*, 347–355, https://doi.org/10.1037/men0000168.

Berry, T., & Howe, H. (2000). Risk factors for disordered eating in female university athletes. *J Sport Behav*, *23*, 207–218.

Bert, F., Gualano, M. R., Voglino, G., Rossello, P., Perret, J. P., & Siliquini, R. (2019). Orthorexia Nervosa: A cross-sectional study among athletes competing in endurance sports in Northern Italy. *PloS one*, *14*(8), e0221399, https://doi.org/10.1371/journal.pone.0221399.

Bolles, J., Long, B., & Fiorentino, L. H. (2005). The Prevalence of Anorexia Athletica in NCAA Division II Athletes. *The International Journal of Kinesiology in Higher Education, 26(2),* 12–17.

Bratland-Sanda, S., & Sundgot-Borgen, J. (2012). Eating disorders in athletes: Overview of prevalence, risk factors and recommendations for prevention and treatment, *European Journal of Sport Science*, https://doi.org/10.1080/17461391.2012.74050.

Brytek-Matera, A. (2021). *Eating disorders*. Warsaw: PZWL Medical Publishing House

Bundros, J., Clifford, D., Silliman, K., & Neyman Morris, M. (2016). Prevalence of Orthorexia nervosa among college students based on Bratman's test and associated tendencies. *Appetite*, 101, 86–94. https://doi.org/10.1016/j.appet.2016.02.144 2692374.

Byrne, S., & McLean, N. (2002). Elite athletes: Effects of the pressure to be thin. *Journal of Science and Medicine in Sport*, *5*(2), 80–94, https://doi.org/10.1016/S1440-2440(02)80029-9.

Cena, H., Barthels, F., Cuzzolaro, M., Bratman, S., Brytek-Matera, A., Dunn, T., Varga, M., Missbach, B., & Donini, L.M. (2019). Definition and diagnostic criteria for orthorexia nervosa: a narrative review of the literature. *Eat Weight Disord*, *24*(2), 209–246, https://doi.org/10.1007/s40519-018-0606-y.

Chapa, D. A. N., Johnson, S. N., Richson, B. N., Bjorlie, K., Won, Y. Q., Nelson, S. V., Ayres, J., Jun, D., Forbush, K. T., Christensen, K. A., & Perko, V. L. (2022). Eating-disorder psychopathology in female athletes and non-athletes: A meta-analysis. *The International journal of eating disorders*, *55*(7), 861–885, https://doi.org/10.1002/eat.23748.

Chatterton, J. M., & Petrie, T. A. (2013). Prevalence of disordered eating and pathogenic weight control behaviors among male collegiate athletes. *Eat Disord*. *21*(4), 328–41, https://doi.org/10.1080/10640266.2013.797822.

Coelho, G. M., Gomes, A. I., Ribeiro, B. G., & Soares, E.de A. (2014). Prevention of eating disorders in female athletes. *Open access journal of sports medicine*, *5*, 105–113, https://doi.org/10.2147/OAJSM.S36528.

Culbert, K. M., Racine, S. E., Klump, K. L. (2015). Research Review: What we have learned about the causes of eating disorders: a synthesis of sociocultural, psychological, and biological research. *J Child Psychol Psychiatry*, *56*, 1141–64, https://doi.org/10.1111/jcpp.12441.

Currie A. (2010). Sport and eating disorders - understanding and managing the risks. *Asian journal of sports medicine*, *1*(2), 63–68, https://doi.org/10.5812/asjsm.34864.

Dakanalis, A., Clerici, M., Caslini, M., Gaudio, S., Serino, S., Riva, G., Carrà, G. (2016). Predictors of initiation and persistence of recurrent binge eating and inappropriate weight compensatory behaviors in college men. *Int J Eat Disord*, *49*, 581–590, https://doi.org/10.1002/eat.22535.

Daubresse, A., Meignie, A., Antero, J., Hanon, C., Mériaux-Scoffier, S. (2024). Dysfunctional eating attitudes and behaviors among French elite athletes: the impact of psychological characteristics and the sporting calendar. *Front Psychol.* https://doi.org/10.3389/fpsyg.2024.1423772.

Donini, L. M., Marsili, D., Graziani, M. P., Imbriale, M., & Cannella, C. (2004**).** *Orthorexia Nervosa***:** A Preliminary Study with a Proposal for Diagnosis and an Attempt to Measure the Dimension of the Phenomenon. *Eat. Weight Disord. 9*, 151–157, https://doi.org/10.1007/BF03325060.

Donini, L. M., Barrada, J. R., Barthels, F., Dunn, T. M., Babeau, C., Brytek-Matera, A., Cena, H., Cerolini, S., Cho, H. H., Coimbra, M., Cuzzolaro, M., Ferreira, C., Galfano, V., Grammatikopoulou, M. G., Hallit, S., Håman, L., Hay, P., Jimbo, M., Lasson, C., Lindgren, E. C., & Lombardo, C. (2022). A consensus document on definition and diagnostic criteria for orthorexia nervosa. *Eating and weight disorders: EWD*, *27*(8), 3695–3711, https://doi.org/10.1007/s40519-022-01512-5.

Dunn, T.M., & Bratman, S. (2016). On orthorexia nervosa*:* a review of the literature and proposed diagnostic criteria*. Eat Behav, 21*, 11–17, https://doi.org/10.1016/j.eatbeh.2015.12.006.

Eichstadt, M., Luzier, J., Cho, D., & Weisenmuller, C. (2020). Eating Disorders in Male Athletes. *Sports health*, *12*(4), 327–333, https://doi.org/10.1177/1941738120928991.

El Ghoch, M., Soave, F., Calugi, S., & Dalle, G.R. (2013). Eating disorders, Physical Fitness and Sport Performance: A Systematic Review. *Nutrients*, *5*, 5140–60, https://doi.org/10.3390/nu5125140.

Engel, S., Johnson, C., Powers, P., Crosby, R., Wonderlich, S., Wittrock, D., Mitchell, E. J. (2003). Predictors of disordered eating in a sample of elite Division I college athletes. *Eat Behav*, 4, 333–343, https://doi.org/10.1016/S1471-0153(03)00031-X.

Gałecki, P., Pilecki, M., Rymaszewska, J. Szulc, A., Sidorowicz, S., Wciórka, J. (2018). *Diagnostic criteria for DSM-5 mental disorders*, Wrocław: Edra Urban & Partner

Ghazzawi, H. A., Nimer, L. S, Haddad, A. J., Alhaj, O. A., Amawi, A. T., Pandi-Perumal, S. R., Trabelsi, K., Seeman, M. V., & Jahrami, H. (2024). A systematic review, meta-analysis, and meta-regression of the prevalence of self-reported disordered eating and associated factors among athletes worldwide. *J Eat Disord*, *7*,12(1)-24. https://doi.org/10.1186/s40337-024-00982-5. PMID: 38326925; PMCID: PMC10851573.

Giel, K. E., Hermann-Werner, A., Mayer, J., Diehl, K., Schneider, S., Thiel, A., Zipfel, G. (2016). Eating disorder pathology in elite adolescent athletes. *Int J Eat Disord, 49*, 553–62, https://doi.org/10.1002/eat.22511.

Goldfield, G. S., & Woodside, D. B. (2009). Body image, disordered eating, and anabolic steroids in male bodybuilders: current versus former users. *The Physician and sportsmedicine*, *37*(1), 111–114, https://doi.org/10.3810/psm.2009.04.1690.

Hagmar, M., Hirschberg, A. L., Berglund, L., & Berglund, B. (2008). Special attention to the weight-control strategies employed by Olympic athletes striving for leanness is required. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *18*(1), 5–9, https://doi.org/10.1097/JSM.0b013e31804c77bd.

Hausenblas, H. A., & Carron, A. V. (1999). Eating disorder indices and athletes: An integration. *Journal of Sport & Exercise Psychology*, 21(3), 230–258, doi: 10.1123/jsep.21.3.230.

Homan K. (2010). Athletic-ideal and thin-ideal internalization as prospective predictors of body dissatisfaction, dieting, and compulsive exercise. *Body image*, *7*(3), 240–245, https://doi.org/10.1016/j.bodyim.2010.02.004

Jaššová, K., & Dostal, J. (2022). Eating disorders in elite sport. *Medicina Sportica Biohemica & Slovaca, 31*, 4.

Krentz, E. M., & Warschburger, P. (2013). A longitudinal investigation of sports-related risk factors for disordered eating in aesthetic sports. *Scand J Med Sci Sports*, *23*(3), 303–10, https://doi.org/10.1111/j.1600-0838.2011.01380.x.

Kristjansdottir, H. Sigurðardóttir, P., Jónsdóttir, S., Þorsteinsdóttir, G., & Saavedra, J. (2019). Body image concerns and eating disorder symptoms among elite Icelandic athletes. International *Journal of Environmental Research & Public Health*, *31*;16(15), https://doi.org/10.3390/ijerph16152728.

Landkammer, F., Winter, K., Thiel, A., Sassenberg, K. (2019). Team Sports Off the Field: Competing Excludes Cooperating for Individual but Not for Team Athletes. *Front. Psychol*, *10*, 2470, https://doi.org/10.3389/fpsyg.2019.02470.

Lee, B. L. (2024). Low energy availability (LEA) in male athletes: A review of the literature. *The Sport Journal*, 29.

Ljungqvist, A., Jenoure, P. J., Engebretsen, L., Alonso, J. M., Bahr, R., Clough, A. F., de Bondt, G., Dvorak, J., Maloley, R., Matheson, G., Meeuwisse, W., Meijboom, E. J., Mountjoy, M., Pelliccia, A., Schwellnus, M., Sprumont, D., Schamasch, P., Gauthier, J. B., & Dubi, C. (2009). The International Olympic Committee (IOC) consensus statement on periodic health evaluation of elite athletes, March 2009. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *19*(5), 347–365, https://doi.org/10.1097/JSM.0b013e3181b7332c

Łuszczyńska, A. (2014). *Psychology of sport and physical activity: clinical issues.* Warsaw: PWN Scientific Publishing House.

Magee, M. K., Jones, M. T., Fields, J. B., Kresta, J., Khurelbaatar, C., Dodge, C., Merfeld, B., Ambrosius, A., Carpenter, M., & Jagim, A. R. (2023). Body Composition, Energy Availability, Risk of Eating Disorder, and Sport Nutrition Knowledge in Young Athletes. *Nutrients, 15*(6), 1502, https://doi.org/10.3390/nu15061502

Mancine, R. P., Gusfa, D. W., Moshrefi, A., & Kennedy, S. F. (2020). Prevalence of disordered eating in athletes categorized by emphasis on leanness and activity type - a systematic review. *Journal of eating disorders*, *8*, 47, https://doi.org/10.1186/s40337-020-00323-2

Martinsen, M., Bratland-Sanda, S., Eriksson, A. K., & Sundgot- Borgen, J. (2010). Dieting to win or to be thin? A study of dieting and disordered eating among adolescent elite athletes and non-athlete controls. *British Journal of Sports Medicine*, *44*(1), 70–76.

McComb, S. E., Mills, J. S. (2019). Orthorexia nervosa: A review of psychosocial risk factors. *Appetite,* 140, 50–75, https://doi.org/10.1016/j.appet.2019.05.005

Meule, A., & Voderholzer, U. (2021). Orthorexia Nervosa-It Is Time to Think About Abandoning the Concept of a Distinct Diagnosis. *Frontiers in psychiatry*, *12*, 640401. https://doi.org/10.3389/fpsyt.2021.640401.

Mountjoy, M., Sundgot-Borgen, J. K., Burke, L. M., Ackerman, K. E., Blauwet, C., Constantini, N., Lebrun, C., Lundy, B., Melin, A. K., Meyer, N. L., Sherman, R. T., Tenforde, A. S., Klungland Torstveit, M., & Budgett, R. (2018). IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *British journal of sports medicine*, *52*(11), 687–697, https://doi.org/10.1136/bjsports-2018-099193

Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., Warren, M. P., & American College of Sports Medicine (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and science in sports and exercise*, *39*(10), 1867–1882, https://doi.org/10.1249/mss.0b013e318149f11.1

Nattiv, A., Quah, C., Camargo, K., Lee, A., & Kim, H. (2021). Male Athlete Triad: An emerging syndrome of relative energy deficiency with impaired bone health and hypogonadotropic hypogonadism. *Current Sports Medicine Reports*, *20*(9), 467–476.

Nielson, H. E., Reel, J. J., Galli, N. A., Crookston, B. T., & Miyairi, M. (2013). Body Image and Westernization Trends among Japanese Adolescents.

Oberle, C. D., Watkins, R. S., Burkot, A. (2017). Orthorexic eating behaviors related to exercise addiction and internal motivations in a sample of university students. *Eat Weight Disord*, *23*, 67 – 74. https://doi.org/10.1007/s40519-017-0470-1 29260414.

Õnnik, L., Mooses, M., Suvi, S., Haile, D. W., Ojiambo, R., Lane, A. R., & Hackney, A. C. (2022). Prevalence of Triad-RED-S symptoms in high-level Kenyan male and female distance runners and corresponding control groups. *European journal of applied physiology*, *122*(1), 199–208, https://doi.org/10.1007/s00421-021-04827-w.

Petrie, T. A., & Greenleaf, C. A. (2007). Eating disorders in sport: From theory to research to intervention. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of sport psychology* (3rd ed., pp. 352–378). John Wiley & Sons, Inc.

Petrie, T. A. (2020). Eating disorders in sport: From etiology to prevention. In G. Tenenbaum, R. C. Eklund, & N. Boiangin (Eds.), *Handbook of sport psychology: Social perspectives, cognition, and applications* (4th ed., pp. 694–710). John Wiley & Sons, Inc, https://doi.org/10.1002/9781119568124.ch33.

Petrović, I. (2020). Does the female athlete triad really exist? *Facta Universitatis: Series Physical Education & Sport,*18(1), 37-48, https://doi.org/10.22190/FUPES191019005P.

Rosendahl, J., Bormann, B., Aschenbrenner, K., Aschenbrenner, F., & Strauss, B. (2009). Dieting and disordered eating in German high school athletes and non-athletes. *Scand J Med Sci Sports, 19*(5), 731–9, https://doi.org/10.1111/j.1600-0838.2008.00821.x.

Rousselet, M., Guérineau, B., Paruit, M.C., Guinot, M., Lise, S., Destrube, B., Ruffio- Thery, S., Dominguez, N., Brisseau-Gimenez, S., Dubois, V., Mora, C., Trolonge, S., Lambert, S., Grall-Bronnec, M., & Prétagut, S. (2017). Disordered eating in French high- level athletes: association with type of sport, doping behavior, and psychological features. *Eat Weight Disord, 22*(1), 61–8, https://doi.org/10.1007/s40519-016-0342-0.

Rumball, J. S., & Lebrun, C. M. (2004). Preparticipation physical examination: selected issues for the female athlete. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine, 14*(3), 153–160, https://doi.org/10.1097/00042752-200405000-00008.

Selby, C. L. B., & Reel, J. J. (2011). A Coach's Guide to Identifying and Helping Athletes with Eating Disorders. *Journal of Sport Psychology in Action*, *2*, 100–112, https://doi.org/10.1080/21520704.2011.585701.

Silen, Y., & Keski-Rahkonen, A. (2022). Worldwide prevalence of DSM-5 eating disorders among young people. *Curr Opin Psychiatry*. 35(6): p. 362–371, https://doi.org/10.1097/YCO.0000000000000818.

Smolak, L., Murnen, S. K., & Ruble, A. E. (2000). Female athletes and eating problems: a meta-analysis. *The International journal of eating disorders*, *27*(4), 371–380. https://doi.org/10.1002/(sici)1098-108x(200005)27:4<371:aid-eat1>3.0.co;2-y

Stice, E., & Shaw, H. E. (2002). Role of body dissatisfaction in the onset and maintenance of eating pathology: a synthesis of research findings. *Journal of psychosomatic research*, *53*(5), 985–993, https://doi.org/10.1016/s0022-3999(02)00488-9.

Sudi, K., Ottl, K., Payerl, D., Baumgartl, P., Tauschmann, K., & Meueller, W. (2004). Anorexia athletica. *Nutrition, 20*, 657–661, https://doi.org/10.1016/j.nut.2004.04.019.

Sundgot-Borgen, J. (1993). Prevalence of eating disorders in elite female athletes. *International Journal of Sport Nutrition*, *3*(1), 29–40. https://doi.org/10.1123/ijsn.3.1.29.

Sundgot-Borgen, J. (1994). Eating disorders in female athletes. *Sports Med,* 17, 176–188, https://doi.org/10.1123/ijsn.3.1.29.

Sundgot-Borgen, J., & Torstveit, M. K. (2004). Prevalence of eating disorders in elite athletes is higher than in the general population. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *14*(1), 25–32, https://doi.org/10.1097/00042752-200401000-00005.

Szewczyk, O., Olek, E., Czarnecka, K., Korczak, A., Burda, K., Wójcik, E., … & Jędrzejczyk, J. (2024). Eating disorders among professional athletes. A narrative review. *Quality in Sport*, *17*, 52963, https://doi.org/10.12775/QS.2024.17.52963

Thompson, R. A., & Sherman, R. T. (1999). Athletes, athletic performance, and eating disorders: Healthier alternatives. *Journal of Social Issues, 55*(2), 317–337, https://doi.org/10.1111/0022-4537.00118.

Thompson, R. A., & Sherman, R. T. (2010). *Eating disorders in sport.* Routledge/Taylor & Francis Group, https://doi.org/10.4324/9780203879856.

Torstveit, M. K., Rosenvinge, J. H., & Sundgot-Borgen, J. (2008). Prevalence of eating disorders and the predictive power of risk models in female elite athletes: a controlled study. *Scand J Med Sci Sports, 18*(1), 108–18, https://doi.org/10.1111/j.1600-0838.2007.00657.x.

Wells, K. R., Jeacocke, N. A., Appaneal, R., Smith, H. D., Vlahovich, N., Burke, L. M., & Hughes, D. (2020). The Australian Institute of Sport (AIS) and National Eating Disorders Collaboration (NEDC) position statement on disordered eating in high performance sport. *Br J Sports Med.*, *21*,1247–58, https://doi.org/10.1136/bjsports-2019-101813.

Cite this article as: Kaliczyńska, L. (2025). Eating Disorders in Sport: A Narrative Review of Studies on Eating Disorders Among Athletes. *Central European Journal of Sport Sciences and Medicine*, *3*(51), 73–86. https://doi.org/10.18276/cej.2025.3-06