Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 5, 1260-1268
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i5.1829

Metabolic syndrome and its clinical and laboratory indicators in relation to outdoor physical activities: Walking, Nordic walking, and cycling

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Abstract: Aim of the study is to investigate the relationship between outdoor walking and sports activities and the clinical and laboratory indicators of metabolic syndrome. Data for the research were collected through the use of questionnaires, anthropometric measurements, and laboratory tests. Using the National Diabetes Federation guidelines, the data were analyzed to determine whether the respondent had metabolic syndrome. Data analysis was conducted on a sample of 380 patients with metabolic syndrome. The study was conducted through quantitative analysis of cross-sectional data. The descriptive part involved conducting variable frequency and cross-tabulation analysis. Odds ratios were calculated using univariate and multivariate logistic regression models. The odds of increased glycosylated hemoglobin (HbA1c) were 1.8-fold lower in the physically active group than in the non-exercise group (the adjusted odds ratio model for sex, age, and smoking (aOR) = 0.56, 95% confidence interval (CI) 0.34–0.95). The odds of reduced high-density cholesterol (HDL-cholesterol) were three times lower in the physically active group than in the non-exercise group (aOR = 0.29, 95% CI 0.18–0.48). The odds of obesity were 3.7 times lower among patients who exercised than among those who did not (aOR = 0.27, 95% CI 0.10–0.68). Outdoor physical activities have a statistically significant effect on HbA1c levels, HDL-cholesterol, and obesity in patients with metabolic syndrome. Metabolic syndrome patients can be advised to engage in physical activities in order to improve their health.
Keywords: *Glycosylated hemoglobin, Metabolic syndrome, Obesity, Physical activities.*

1. Introduction

Metabolic syndrome is a set of symptoms that increase the risk of cardiovascular disease, stroke, and type 2 diabetes mellitus. Metabolic syndrome can be diagnosed if at least three of the following criteria are present [1]: arterial hypertension (characteristic values of arterial blood pressure > 130/85 mm/Hg, or patients with arterial hypertension taking antihypertensives); triglycerides > 1.7 mmol/l, or medical treatment of hypertriglyceridemia; fasting blood glucose level > 5.6 mmol/l, or medical treatment of hyperglycaemia; high-density lipoprotein (HDL) level < 1.0 mmol/l; waist circumference > 94 cm in men and > 85 cm in women, which in turn lead to abdominal obesity. Metabolic syndrome is closely related to excess weight or obesity and a sedentary lifestyle, resulting in insulin resistance. Insulin resistance arises as a result of obesity, where muscle and liver cells exhibit inadequate responsiveness to insulin and are unable to utilize glucose for energy. To compensate, the pancreas increases its production of insulin [2], but this surplus is not effectively utilized. Consequently, there is an elevation in blood glucose levels, leading to the development of prediabetes, which may eventually progress to diabetes [3]. Metabolic syndrome disrupts the functioning of other endocrine glands. In men, this can cause a decrease in testosterone synthesis in the testicles and the

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development of hypogonadism [4]. A more effective approach to monitoring blood glucose levels is to measure glycosylated hemoglobin (HbA1c) rather than directly measuring glucose levels. This indicator shows the average blood glucose level during a span of three months. If the value of this indicator is ≤ 7%, it is considered that diabetes compensation is satisfactory 5]. Physical activity is crucial in the management of obesity. Engaging in a daily 30-minute walk can enhance cardiovascular health, strengthen bones, and diminish surplus body fat. These benefits subsequently decrease the likelihood of developing heart disease, type 2 diabetes, and metabolic syndrome [6, 7, 8]. Engaging in regular physical activity is an effective measure for preventing the onset of type 2 diabetes in overweight individuals with impaired glucose tolerance [9]. Environmental biological factors, such as fresh air and proximity to natural environments like the sea or forest, have the potential to enhance the human body's healing mechanisms [10]. This study aimed to examine the relationship between outdoor walking and sports activities and the clinical and laboratory indicators of metabolic syndrome.

2. Materials and Methods

The study included 380 patients diagnosed with metabolic syndrome (MS) from three general practitioner (GP) practices in Daugavpils, Latvia. The permission of the Ethics Committee of Daugavpils University was obtained for the study. The participants were categorized into two groups: Group 1 consisted of MS patients who engaged in outdoor walking and sports activities, while Group 2 comprised non-exercising MS patients. Patient inclusion criteria. Participants aged 18 to 90 years diagnosed with MS who gave their consent to take part in the study. Patient exclusion criteria. Decompensated diseases, terminal stage of oncological pathology, diseases characterized by significant cognitive deterioration and impeding contact with patient, age less than 18 or greater than 90 years. An analysis was conducted on the outpatient medical records of the patients. The study focused on the following indicators: total cholesterol (TC), HDL, triglycerides (TG), and HbA1c. These indicators were only included if they had been tested within the past 6 months. The study participants' waist circumference, height, weight, and blood pressure (BP) were assessed, and their body mass index (BMI) was calculated. Confirmation of diagnosis. The diagnosis of MS was determined based on the guidelines provided by the International Diabetes Federation and the American Heart Association/National Heart, Lung, and Blood Institute [1]. Hypertriglyceridemia was diagnosed when triglyceride levels were ≥1.7 mmol/L. Reduced HDL was defined as less than 1.0 mmol/L. HbA1c levels of ≤ 7% were considered normal, while levels of > 7% were considered pathological. A waist circumference of ≤ 80 cm was considered normal for women, and ≤ 94 cm for men. We used the currently available hypertension diagnostic system recommended by the European Society of Hypertension and the European Society of Cardiology [11], where the optimal blood pressure (BP) level is < 120/80; normal BP: 120–129/80–84; high normal BP: 130–139/85–89; stage 1 hypertension: 140–159/90–99; stage 2 hypertension: 160–179/100–109; and stage 3 hypertension: > 180/> 110. Obesity was diagnosed based on the modern World Health Organization (WHO) classification principles depending on the body mass index. Normal weight corresponds to a BMI of 18.5–24.99 kg/m^2, overweight – to 25–29.99 kg/m^2, obesity – to 30–39.99 kg/m^2, and severe obesity – to over 40 kg/m^2 [12]. The study participants were surveyed regarding their outdoor sports activities, including the frequency and duration of each workout, and the duration of their engagement in sports. The study examined smoking as a major confounding factor, assuming that smoking, regardless of other variables, may exacerbate laboratory and clinical indicators of MS. The survey results were documented in the survey questionnaire Table 1.

Table 1.
Respondent survey questionnaire.

Date: **Respondent ID:**	
Age (In years):	
Sex:	☐ Female ☐ Male
Diagnosis:	
Do you take antihypertensive medications?	☐ Yes ☐ No
Do you take antidiabetic medications?	☐ Yes ☐ No
Do you smoke?	☐ Yes ☐ No
Do you do any of these physical activities outdoors?	☐ Walking ☐ Nordic walking ☐ Cycling
How many times a week?	
What is the length of the activity? (In minutes)	
How long have you been doing it?	

The data processing involved a cross-sectional quantitative data analysis, which was conducted using the software SPSS 23.0 and MS Office Excel. The descriptive part involved conducting variable frequency and cross-tabulation analysis. Statistical significance was determined for variations in different groups of variables based on the primary substance used if the p-value was less than 0.05 ($p < 0.05$). Univariate and multivariate logistic regression models of multinomial logistic regression were used to calculate odds ratios. The statistical significance of the OR was assessed using a 95% confidence interval (CI). If the value of 1.00 was not included in the 95% confidence interval (CI), the results were deemed to be statistically significant. Two multivariate regression models were created: aOR^1 (adjusted odds ratio^1) – the model adjusted for sex and age and aOR^2 (adjusted odds ratio^2) – the model adjusted for sex, age, and smoking.

3. Results

See Table 2 and Table 3 for baseline characterization of the study population.

Table 2.
Characteristics of the study participants by sex.

		Frequency	**Percentage**
Sex	Male	145	38.2
	Female	235	61.8
	Total	380	100.0

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 5: 1260-1268, 2024
DOI: 10.55214/25768484.v8i5.1829

Table 3.
Distribution of participants by age group.

		Frequency	Percentage
Age (In years)	<50	24	6.3
	50-59	62	16.3
	60-69	94	24.7
	70-79	156	41.1
	80 and older	44	11.6
	Total	380	100.0

32.1% of the study participants (n = 122) reported engaging in physical activities such as walking, Nordic walking, or cycling. The remaining 67.9% did not participate in physical activities. The majority of participants, specifically 87.1% (n = 331), were diagnosed with arterial hypertension. 71.8% (n = 273) of respondents were classified as obese, one fifth, or 21.8% (n = 83) were overweight, 0.3% (n = 1) were underweight, and only 6.1% (n = 23) had a normal body weight. The majority of the study participants, specifically 91% (n = 371), had an increased waist circumference, while only 2.4% (n = 9) met the target waist circumference recommended by WHO. Hypertriglyceridemia was found in more than a third of patients, or 38.7% (n = 147). Almost a third of patients, or 28.9% (n = 110), had HbA1c > 7%, which is indicative of inadequate glycemic control. Almost half of the study participants, or 45.8% (n = 174), had reduced HDL levels. The majority of patients took antidiabetic medications (85.8%, n = 326) and antihypertensive medications (87.1%, n = 331). Out of the study participants, 23.7% (n = 90) were smokers, while 76.3% (n = 290) were non-smokers.
Relationship between health indicators and physical activities is demonstrated in Table 4.

Table 4.
Differences in participants' health indicators across physical activity groups.

Differences in health indicators across physical activity groups, %			
Physical activity	**Yes**	**No**	**p-value**
Hypertension			
Yes	85.2%	88.0%	p = 0.457
No	14.8%	12.0%	
Total	100%	100%	
Hypertriglyceridemia			
Yes	15.6%	49.6%	p < 0.001
No	84.4%	50.4%	
Total	100%	100%	
HbA1c, %			
>7 %	21.3%	32.6%	p = 0.024
≤7%	78.7%	67.4%	
Total	100%	100%	
Reduced HDL-cholesterol			
Yes	29.5%	53.5%	p < 0.001
No	70.5%	46.5%	
Total	100%	100%	
BMI			
Excess body weight	34.4%	16.0%	p < 0.001
Obesity	55.7%	79.8%	
Normal body weight	9.8%	4.3%	

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 5: 1260-1268, 2024
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Total	100%	100%	
Waist circumference			
Target	3.3%	1.9%	p = 0.003
Total	100%	100%	
Antidiabetic medications			
Yes	81.1%	88.0%	p = 0.075
No	18.9%	12.0%	
Total	100%	100%	
Antihypertensive medications			
Yes	85.2%	88.0%	p = 0.457
No	14.8%	12.0%	
Total	100%	100%	
Smoking			
Yes	21.3%	24.8%	p = 0.454
No	78.7%	75.2%	
Total	100%	100%	

No significant differences in the prevalence of hypertension based on physical activity were found (p = 0.457). Among physically active patients, hypertension was observed in 85.2% (n = 104/122), whereas among non-exercising patients, it was observed in 88.0% (n = 227/258). The occurrence of hypertriglyceridemia was significantly lower in physically active participants compared to non-exercising patients, with rates of 15.6% (n = 19/122) and 49.6% (n = 128/258), respectively (p < 0.001). HbA1c > 7% was found more often among patients who did not engage in physical activities than among those who were physically active, i.e. 32.6% (n = 84/258) and 21.3% (n = 26/122) respectively, (p = 0.024). The prevalence of reduced HDL levels among physically active respondents was statistically significantly lower (29.5%, n = 36/122) than among non-exercising respondents (53.5%, n = 138/258), (p < 0.001). BMI varied significantly based on the level of physical activity, (p < 0.001). Obesity was statistically lower among physically active participants (85.0%) than among non-exercising patients (94.9%), p = 0.005. Nevertheless, there were no statistically significant disparities observed between individuals with normal body weight and those with excess body weight in relation to physical activity (p = 1.0). No differences in target waist circumference were identified between physically active and non-exercise groups. The prevalence of antidiabetic medication use was similarly high in both physically active participants (81.1%, n = 99/122) and those who did not engage in physical activity (88.0%, n = 227/258), (p = 0.075). No differences in the use of antihypertensive medications were found in the physical activity groups (p = 0.457). Among the participants who engaged in physical activities, the prevalence of antihypertensive medication use was 85.2% (n = 104/122), and among the participants who did not engage in physical activities it was 88.0% (n = 227/258). The prevalence of smoking depending on physical activity was similar both among physically active participants (21.3%, n = 26/122) and among non-exercising participants (24.8%, n = 64/258), (p = 0.454).

Relationship between demographic and health factors and physical activity through the use of logistic regression (odds ratio). Using logistic regression analysis, it was determined that individuals who participated in physical activities had 1.3 times lower odds of hypertension (OR = 0.79, 95% CI 0.42–1.47) than those who did not engage in physical activities, but the relationship was not statistically significant. Physically active patients had 5.3 times lower odds of hypertriglyceridemia (OR = 0.19, 95% CI 0.11–0.32) than those who were not physically active, with results being statistically significant. The odds ratio (OR) for physically active participants having elevated HbA1c was 0.56 (95% CI 0.34–0.93), indicating that they were 1.7 times less likely to have elevated HbA1c compared to non-exercising participants, with the relationship being statistically significant. Respondents who engaged in physical activity were almost three times less likely to have a reduced HDL level than those who were not physically active (OR = 0.36, 95% CI 0.23–0.58), with results being statistically significant. Patients who engaged in physical activity had a statistically significant three times lower (OR = 0.30, 95% CI 0.13– 0.72) odds of obesity than those who did not engage in physical activity. Patients who engaged in physical activity had 1.06 times lower odds (OR = 0.94, 95% CI 0.37–2.37) of having excess weight compared to patients who did not exercise. However, this relationship did not reach statistical significance. No statistically significant relationship was found between physical activity and waist circumference. The relationship between physical activity and medication use was not statistically significant. Participants who were physically active were almost twice less likely (OR = 0.59, 95% CI 0.33–1.06) to use antidiabetic medication and 1.3 times less likely (OR = 0.79, 95% CI 0.42–1.47) to use antihypertensive drugs than non-exercising participants, but the difference was not statistically significant. Patients who were physically active had 1.2 times lower odds (OR = 0.82, 95% CI 0.49–1.38) of smoking compared to those who did not participate in physical activity. However, this relationship did not reach statistical significance Table 5.

Table 5.
Effects of participants' physical activities on MS symptoms, smoking, and medication use.

Physical activity yes vs no	OR (95% CI)
Hypertension	
Yes	0.79 (0.42 - 1.47)
No	Ref.
Hypertriglyceridemia	
Yes	0.19 (0.11 – 0.32)
No	Ref.
HbA1c, %	
>7 %	0.56 (0.34 – 0.93)
≤7%	Ref.
Reduced HDL-cholesterol	
Yes	0.36 (0.23 – 0.58)
No	Ref.
BMI	
Excess body weight	0.94 (0.37 – 2.37)
Obesity	0.30 (0.13 – 0.72)
Normal body weight	Ref.
Waist circumference	
Increased	1.43 (0.34 – 6.03)
Target	Ref.
Antidiabetic medications	
Yes	0.59 (0.33 – 1.06)
No	Ref.
Antihypertensive medications	
Yes	0.79 (0.42 – 1.47)
No	Ref.
Smoking	
Yes	0.82 (0.49 – 1.38)
No	Ref.

Relationship between demographic and health factors and physical activity (multivariate regression models). Both multivariate regression models, which were adjusted for sex and age (aOR[1]) and further adjusted for smoking (aOR[2]), showed that physically active patients had significantly lower odds of hypertriglyceridemia, increased HbA1c, reduced HDL-cholesterol, and obesity compared to non-exercising patients. The odds of hypertriglyceridemia among the participants who engaged in physical activity were seven times lower than among those who did not engage in physical activity (aOR[2] = 0.14, 95% CI 0.08 – 0.25).

Table 6.
Relationship between physical activities and health indicators (Multivariate regression models).

Physical activity yes vs no	**aOR[1] (95% CI)**	**aOR[2] (95% CI)**
Hypertension		
Yes	1.00 (0.51 - 1.98)	0.92 (0.46 -1.83)
No	Ref.	Ref.
Hypertriglyceridemia		
Yes	0.13 (0.07 – 0.24)	0.14 (0.08 – 0.25)
No	Ref.	Ref.
HbA1c, %		
>7 %	0.56 (0.33 – 0.94)	0.56 (0.34 – 0.95)
≤7%	Ref.	Ref.
Reduced HDL-cholesterol		
Yes	0.29 (0.18 – 0.47)	0.29 (0.18 – 0.48)
No	Ref.	Ref.
BMI		
Excess body weight	0.96 (0.37 – 2.55)	0.98 (0.36 – 2.65)
Obesity	0.26 (0.10 – 0.65)	0.27 (0.10 – 0.68)
Normal body weight	Ref.	Ref.
Waist circumference		
Increased	1.17 (0.25 – 5.42)	1.20 (0.26 – 5.58)
Target	Ref.	Ref.
Antidiabetic medications		
Yes	0.60 (0.32 – 1.10)	0.61 (0.33 – 1.13)
No	Ref.	Ref.
Antihypertensive medications		
Yes	1.00 (0.51 – 1.98)	0.92 (0.46 – 1.83)
No	Ref.	Ref.
Smoking		
Yes	0,68 (0,34 – 1,34)	0.68 (0.34 – 1.34)
No	Ref.	Ref.

Note: The models reflect the relationship between health indicators and physical activities.
aOR[1] – adjusted odds ratio for sex and age
aOR[2]– adjusted odds ratio for sex, age, and smoking
95% CI – a 95% confidence interval
Statistically significant relationships are given in bold, 95% CI excludes 1.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 5: 1260-1268, 2024
DOI: 10.55214/25768484.v8i5.1829

The odds of increased HbA1c were 1.8 times lower in physically active patients than in those who did not engage in physical activity (aOR^2 = 0.56, 95% CI 0.34 – 0.95). The odds of reduced HDL-cholesterol in the physically active patient group were three times lower than in the group of patients who did not participate in physical activity (aOR^2 = 0.29, 95% CI 0.18 – 0.48). The odds of obesity were 3.7 times lower among patients who were physically active than those who were not (aOR^2 = 0.27, 95% CI 0.10 – 0.68). The other factors (hypertension, excess body weight, waist circumference, use of antidiabetic medications, and use of antihypertensive medications) were not statistically reliably related to physical activity Table 6.

4. Discussion

There are numerous publications in medical literature that discuss the beneficial impact of walking in preventing cardiovascular diseases. For instance, a review of studies published in the journal *Current Opinion in Cardiology* revealed that walking may play an important role in the primary and secondary prevention of cardiovascular disease in younger, middle-aged, and older men and women [7]. Studies presented at the American College of Cardiology's 67th Annual Scientific Session indicate that engaging in walking for a minimum of 40 minutes multiple times per week, at a moderate to brisk speed, is linked to a nearly 25% decrease in the likelihood of heart failure among postmenopausal women [13]. According to a study published in the journal *Preventing Chronic Disease* in 2019, walking, particularly among adults with a high risk of cardiovascular disease, can encourage a more active way of life and help prevent and control the risk of cardiovascular disease [8]. Additional research demonstrates the advantageous impacts of physical activity on type 2 diabetes [9]. Currently, there is a limited body of published research examining the impact of physical activity on metabolic syndrome. In a review article, Myers and colleagues provide an overview of the beneficial impacts of physical exercise on various aspects of the metabolic syndrome [14]. In 2021, Korean scientists published a study that demonstrated the beneficial impact of exercise on the metabolism of biomarkers associated with metabolic syndrome in the bloodstream. One of the reasons for the pathogenesis of MS is oxidative stress, which is accompanied by an increased production of mitokines and hepatokines in the mitochondria. Physical activity reduces the concentrations of these substances in the bloodstream [15]. Smith and colleagues (2022) demonstrated the efficacy of exercise in improving indicators of MS in a randomized trial conducted in the United States [16]. Adiposity and a sedentary lifestyle, which are the underlying causes of metabolic syndrome, pose significant challenges in Latvia. The study on Latvian residents' activities revealed that the most common physical activities among residents include walking longer distances (such as to work, school, or other destinations) which was mentioned by 22% of residents, followed by cycling (13%), swimming (10%), and engaging in fitness activities (10%). A mere 11% of Latvian residents participate in sports activities on a daily or near-daily basis. Meanwhile, 26% engage in sports at least three times a week, 37% do so at least twice a week, and 43% participate in sports at least once a week [17]. Therefore, it is important to examine the relationship between sports activities and the elements of the metabolic syndrome in the population of Latvia, as conducted in our study. Consistent with the previously mentioned research, we have shown that walking, cycling, and Nordic walking have a beneficial impact on MS components. Limitation of the study was the size of the population sample. The study only included MS patients from three general practitioner practices, so the findings cannot be generalized to the entire population of Latvia. Additional research involving a larger sample size is required to validate our discoveries.

5. Conclusions

A statistically significant correlation was observed between engaging in outdoor physical activities such as walking, Nordic walking, and cycling, and hypertriglyceridemia, HbA1c level, HDL-cholesterol, and obesity in MS patients. There was no statistically significant impact of engaging in physical activity outdoors on the occurrence of arterial hypertension and waist circumference in MS patients. Engaging in outdoor physical activities such as walking, cycling, and Nordic walking can have a beneficial impact on three MS symptoms. As a result, these activities can be recommended to MS patients as a means to improve their health.

Acknowledgements:
We would like to extend our sincere appreciation to GPs Jeļena Požarska, Ļubova Baranovska, Anatolijs Požarskis and their physician assistants for their invaluable contribution in selecting research patients and for their exceptional work with the patients who participated in the research study.

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