The Austrian Journal of Technical and Natural Sciences, No 7–8
ISSN 2310-5607

PREMIER Publishing
ppublishing.org

Section 3. Medical science

DOI:10.29013/AJT-24-7.8-30-36

HYPODYNAMIA – AS A RISK FACTOR FOR CORONARY HEART DISEASE

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Cite: *Rajabova R. Sh., Nurillaeva N. M. (2024). Hypodynamia - as a risk factor for coronary heart disease. Austrian Journal of Technical and Natural Sciences 2024, No 3–4.* https://doi.org/10.29013/AJT-24-7.8-30-36

Abstract

As the population's income increases, the proportion of their free time on a particular day increases as well. Many people prefer a sedentary lifestyle and rest in their leisure time. Also, due to the improved transport infrastructure, the indication of people's walking activity is decreasing in developed countries. Despite the many beneficial aspects of physical activity, there is a decrease in the number of people following a physically active lifestyle and an increase in the sedentary lifestyle over the globe. To study physical activity depending on human living conditions 183 patients with coronary artery diseases living in rural and urban areas are involved in the research. The standard treatment regimen was combined with an individually-selected physical activity program and administered to the patients during the 6 months. As a result, positive dynamics were observed in terms of lipid spectrum parameters, heart rate, supraventricular and ventricular arrhythmias in both urban and rural populations.

Keywords: *Coronary artery disease, urban and rural population, hypodynamia, physical activity, lipid spectrum, Holter monitoring examination*

Introduction

According to the World Health Organization (WHO) statistics, every fourth of the world's population dies due to hypodynamia, 5.3 million out of 57 million or 9% deaths in 2008 occurred due to hypodynamia (Mendis S, Puska P., Norrving B. editors. 2011).

In recent years, the level of physical activity around the world has been changing according to the following manner: More than a quarter (1.4 billion) of the world's older population is physically inactive, and approximately one in three women and one in four men worldwide are not physically active, physical inactivity rates are twice as high in developed countries as in low-income countries, Since 2001, there has been no increase in the average level of physical activity among the world's population, between 2001 and 2016, the prevalence of physical activity in low-income countries increased by 5% (from 31.6% to 36.8%) when compared to high-income countries (Regina G., Gretchen A. S., Leanne M. R., Fiona C. B., 2018).

Rising levels of physical inactivity have negative impacts on health systems, the environment, economic development, well-being, and quality of life.

Globally, 28% of people over the age of 18 had insufficient physical activity levels (23% of men and 32% of women) in 2016. This suggests that because of the lack of physical activity, people are doing less at least 150 minutes moderate and are doing less at least 75 minutes intensive exercises than the standard recommended for healthy people by WHO (Globally, 1.4 billion adults at risk of disease from not doing enough physical activity).

In high-income countries, 26% of men and 35% of women are physically inactive, compared to 12% of men and 24% of women in low-income countries. This means that as the economic indicators of the countries increase, the physical activity of the population decreases (Globally, 1.4 billion adults at risk of disease from not doing enough physical activity).

As the population's income increases, the share of their daily free time increases. At this time, many prefer a sedentary lifestyle and rest. Also, due to the advanced transport infrastructure in developed countries, the indicators of people's walking are decreasing. In the economy of industrialized countries, as production becomes increasingly automated, the proportion of robotics and smart technologies increases, and the share of the population working in professions that require physical labor tends to decrease. All of the above mentioned reasons are causing the spread of a sedentary lifestyle among the population of countries with a high gross domestic product. Admittedly, the governments of many developed countries are considering the above-mentioned trends and they have been promoting physical activity among the population, walking and using bicycles as a means of transportation (How Artificial Intelligence and Robotics Are Changing Our Lives).

The widespread use of vehicles and the increasing use of modern gadgets for work, education, and recreation are leading to a sedentary lifestyle. According to recent research, the decline in physical activity is causing the following public health problems: the prevalence of obesity in children and adolescents is increasing, the duration of sleep is decreasing, the state of cardiometabolic health and the level of social fitness in children and adolescents is decreasing. Also, it is affecting mental-emotional stability, and the probability of adult death is increasing. In addition to this, the rates of type 2 diabetes and cardiovascular diseases have been increasing dramatically in recent years (Emotional stability (the opposite of neuroticism).

Despite the many beneficial aspects of physical activity, there is a decrease in the population following a physically active lifestyle and an increase in the sedentary lifestyle in most countries of the world. Two principles are used to assess the level of physical activity: physical activity during working hours and during leisure hours. It has been proved that an increase in physical exercise during leisure time has a significant positive effect on health conditions and the prevention of chronic non-infectious diseases. The level of physical activity can change depending on the practical desire of each person (Akulova T. N., Plaksina N. V., Smirnova E. V., 2020).

In 2018, the World Health Organization announced that reducing physical inactivity by 10% among the world's population by 2030 is one of the global goals for achieving the Sustainable Development Goals. To achieve this goal, recommendations have been developed by WHO, and each country is developing national action plans based on these recommendations and implementing them among the population (Global action plan on physical activity 2018–2030).

The purpose of research. To study physical activity depending on human living conditions patients with coronary artery diseases living in rural and urban areas.

Materials and methods

The clinical material for the study was collected in the cardiology and cardio rehabilitation departments of the multidisciplinary clinic of the Tashkent Medical Academy between 2019 and 2021. 183 female and male patients with coronary artery disease (CAD), and stable tension angina pectoris I–III functional class were recruited for the study. The average age of the patients was 64.2 ± ± 5.1 years, 98 of them were men and 85 were women. According to the living conditions of the patients, they were divided into two groups. Group № 1 consisted of 89 (47 men, 42 women) patients with CAD living in urban areas, and 94 (51 men, 43 women) patients with CAD living in rural areas were included in group № 2. All patients do not work in state organizations; they spend most of their time at home.

Patients were enrolled in the study either on admission to the hospital or the next day. Patients were treated as an inpatient for an average of 10 days, after discharge, patients were monitored, and patients underwent re-examination in 3–6 months.

All patients had no contraindications to physical activity and they were informed about the examination before exercise tests, and they signed a consent form. The following cases were not included in the study: acute forms of coronary artery disease, unstable angina, stable angina class IV, heart failure class III–IV according to NYHA, aneurysms of the left ventricle, stage 3 arterial hypertension, severe forms of heart arrhythmias and conduction disorders (all forms of ventricular fibrillation/fibrillation, coupled and early ventricular extrasystole, atrioventricular block second and third degree), an acute cerebral blood circulation disorder, transient ischemic attack, history of thromboembolism, severe concomitant diseases (diseases of the musculoskeletal system, osteoarthrosis and arthritis III X-ray stage, chronic lung, liver, kidney failure), type 1 and type 2 diabetes mellitus.

The diagnosis of CAD was based on the classification adopted at the IV meeting of cardiologists in 2000, and the functional class of the disease was based on the classification of the Canadian Society of Cardiology in 1976.

The clinical characteristics of the patients included in the study are presented in (Table 1).

Table 1. *Clinical characteristics of the patients included in the study*

Clinical features	Group № 1 (n=89)	Group № 2 (n=94)
Average age (years)	65.4 ± 4.3	63.7 ± 5.1
Male	47 (52.8%)	51 (54.3%)
Female	42 (47.2%)	43 (45.7%)
Duration of CAD (years)	4.2 ± 0.33	3.6 ± 0.26
Hypertension	75 (84.3%)	76 (80.8%)
BMI (kg/m2)	30.8	29.7
Abdominal obesity (sm)	118.4	111.8
Smoking	21 (23.6%)	29 (30.8%)

The average age of the 1^{st} group, i.e., the patients with CAD living in the city, was 65.4 ± ± 4.3 years, and the average age of the 2^{nd} group, the patients with CAD living in rural conditions was 63.7 ± 5.1 years. 52.8% of patients in the first group and 54.3% of patients in the second group are males. The majority of patients in both groups were patients with arterial hypertension, i.e. 84.3% and 80.8%, respectively.

Smoking was detected in 1/3 of patients living in rural areas, and in almost ¼ of those living in cities, 23.6% and 30.8%, respectively.

General clinical laboratory examinations, electrocardiogram, echocardiology, cardiac exercise stress test, and Holter monitoring were performed on the patients. Before the study, the patients included in the study underwent a cardiac exercise stress test and an individual physical activity program was created for each patient. Patients were monitored for continuous physical activity for six months.

To determine tolerance to execise stress (ES), all patients underwent a VEM test on a Kettle-ergometer RX1 bicycle ergometer (Germany) according to the protocol for determining the threshold load power with its continuous stepwise increase by 25 W every 3 minutes until the clinical or electrocardiographic criteria for stopping the load or submaximal heart rate (HR) by Andersen (1983) (Bubnova M. G., Aronov D. M., 2016). Clinical criteria for discontinuing the trial were generally accepted. An electrocardiogram (in 12 conventional leads), blood pressure – BP (according to the method of Korotkoff) and heart rate were recorded at the 3^{rd} minute of each load stage, at the peak of the load and in the recovery phase at 1, 3 and 5 minutes.

The following indicators were analyzed: performance and achieved load power, total volume of performed work (TVW), double systolic product (DSP), also the ratio of TVW to the number of heartbeats (HB) for the period of exercise (TVW / HBworking = [HBmax – HBrest] × t / 2) and the sum of the values of DSP during work (TVW / DSPworking = = [DSPmax – DSPrest] × t / 2), which reflect the efficiency of the internal work of the heart during exercise in dynamics or the change in the performed work in terms of one heartbeat and a unit of DSP during exercise. Previously, a bicycle ergometric study was carried out, using the formula (Nikolaeva L. F., Aronov D. M., 1988), the required walking rhythm was calculated for each patient:

$$\mathbf{X = 0.042 \times M + 0.15 \times HR + 65.5}$$

where X – the pace of walking (number of steps / min),

M – threshold load power (kgm / min),

Heart rate – at the peak of the load during bicycle ergometry.

Physical training lasting 50–60 minutes took place 3 times a week for 3 months with the use of intermittent dynamic loads. The training load was 50–60% of the individual threshold load (Bubnova M. G., Aronov D. M., 2016).

Table 2. *Physical activity program based on functional classes of coronary artery disease*

Type of physical activity	Functional class I	Functional class II	Functional class III
General developmental exercises	35–45 minutes	25–35 minutes	20–30 minutes
Dosed walking exercise	30 minutes	20–30 minutes	20 minutes
Breathing exercises	+++	+++	+++
Slow walking exercises	2.5–3.0 km	2.0–2.5 km	1.5–2.0 km

General developmental exercises include small, medium, and partially large joint movements, first in the sitting position, then standing position. Light gymnastic exercises can be performed together with breathing exercises and separately.

"HealthRunApp" – a mobile application that allows the selection of physical activity individually. Prescription of physical activity on the basis of an individually selected innovative approach together with the main treatment of CAD is one of the urgent problems in modern medical healthcare. We have developed "HealthRunApp" – a mobile application that determines individual physical activity and adding these indicators in practice will be a special assistant for the general practitioner, cardiologist, and therapist to assess the positive effect of the physical activity selected for each patient on the treatment efficiency and quality of life. This mobile application can be a good practice assistant for general practitioners, cardiologists, and therapists who are now called family doctors. The mobile application is filled out by the doctor, and the changes in the indicators allow for comparing the dynamics in 3–6 months.

Daily monitoring of ECG. 24-hour ECG monitoring was carried out using the "Poly-Spektr-SM-154" Holter monitoring system (an ambulatory ECG). A 7-channel recorder was used, which allows the creation of 3 monitor connections corresponding to V5, V1, avF electrodes of the standard ECG. During the observation period, the patient's physical activity regimen was observed, they are recommended to sleep no later than 10:00 p.m. and wake up before 7:00 a.m. During the study, patients filled out a diary in which they recorded the type of their activities, their feelings, and the time they took their medications. It was used to compare retrospectively daily patient changes and the characteristics of ECG changes at a given moment of the day.

Interpretation of Holter monitoring data was performed according to the recommendations of the North American Society of Stimulation and Electrophysiology (1999). According to Holter monitoring data, the maximum, minimum and average number of heartbeats, the total number of ventricular extrasystoles and their composition, the number of single, coupled, and group supraventricular extrasystoles and their composition were analyzed. Heart rhythm turbulence, variability, QT interval were evaluated.

Results and discussions

A study of the effect of physical activity on the lipid spectrum of patients with CAD.

Lipid spectrum indicators were determined in all the patients included in the study. Initial and final results were compared. The results of the lipid spectrum of patients are presented in Tables 3. and 4.

Table 3. *Lipid spectrum results in urban-dwelling patients with CAD*

Indicator	Initial		After 6 months	
	Males (n=47)	Females (n=42)	Males (n=47)	Females (n=42)
Total cholesterol, mmol/l	6.54 ± 0.59	6.15 ± 0.55	5.8 ± 0.45	5.56 ± 0.55
TG	2.21 ± 0.22	2.09 ± 0.11	1.8 ± 0.17	1.67 ± 0.12
HDL	0.89 ± 0.02	0.91 ± 0.02	1.03 ± 0.03*	1.06 ± 0.03*
LDL	4.65 ± 0.45	3.73 ± 0.27	3.49 ± 0.29*	3.28 ± 0.28
VLDL	1.05 ± 0.13	1.03 ± 0.12	1.02 ± 0.08	1.01 ± 0.12
Kax	5.85 ± 0.45	5.41 ± 0.49	4.33 ± 0.36*	4.24 ± 0.41

*Note: *–p < 0.05; **p < 0.01; ***p < 0.001*

According to the data presented in (Table 3), it is seen that the amount of HDLP was reliably increased in all patients under the influence of continuous dosed walking exercise for 6 months in combination with standard treatment measures for urban patients with CAD ($p < 0.05$). In male patients, LDL and, correspondingly, Kax also reliably decreased ($r < 0.05$). All patients have a tendency to change the amount of total cholesterol, TG, VLDL in a positive way.

Table 4. *Lipid spectrum results of patients living in a rural area with CAD*

Indicator	Initial		After 6 months	
	Males (n=51)	Females (n=43)	Males (n=51)	Females (n=43)
Total cholesterol, mmol/l	6.67 ± 0.62	6.37 ± 0.59	5.9 ± 0.45	5.9 ± 0.45
TG	2.41 ± 0.27	2.14 ± 0.25	1.94 ± 0.18	1.88 ± 0.17
HDL	0.88 ± 0.02	0.89 ± 0.02	1.01 ± 0.02**	1.03 ± 0.02**
LDL	4.58 ± 0.39	4.27 ± 0.31	3.50 ± 0.29*	3.41 ± 0.27*
VLDL	1.33 ± 0.16	1.21 ± 0.17	1.15 ± 0.09	1.08 ± 0.08
Kax	5.89 ± 0.57	5.66 ± 0.52	4.18 ± 0.33*	4.11 ± 0.33*

Table 4. shows that as a result of continuous dosed walking exercise for 6 months in combination with standard treatment measures for rural patients with CAD, LDL, and correspondingly, Kax in both sexes reliably decreased ($p < 0.05$), it appears that the amount of HDL increased at a highly reliable level ($p < 0.01$).

In this group of patients, there is a tendency for the amount of total cholesterol, TG, VLDL to change in a positive way. Based on the above-mentioned facts, in patients with CAD, positive changes are observed not only under the influence of hypolipidemic agents but also as a result of physical activity.

Especially in HDL, LDL, and Kax indicators.

Evaluation of physical activity-induced Holter monitoring changes in patients with ischemic heart disease

All patients included in the study underwent Holter monitoring during the first

3 days of inpatient treatment. In addition, when the patient was instructed to exercise, Holter monitoring was performed to monitor the safety of exercise. During the Holter monitoring study, the maximum, minimum, and average values of heart rate, supraventricular and ventricular arrhythmias, ST-segment elevation, and QTc values were studied.

Initial and 6-month Holter monitoring results of patients included in the study. given in Tables 5. and 6.

Table 5. *Initial and final (after 6 months) Holter monitoring findings in urban patients with CAD*

Indicator	Initial		After 6 months	
	Males (n=47)	Females (n=42)	Males (n=47)	Females (n=42)
Maximum heart beat	133.9 ± 12.8	129.2 ± 13.6	100.2 ± 9.7*	107.5 ± 11.6
Minimum heart beat	56.9 ± 7.2	59.6 ± 5.7	52.3 ± 4.6	54.6 ± 4.1
Average heart beat	76.2 ± 5.8	73.5 ± 6.6	61.5 ± 4.3*	65.5 ± 5.2
Single Supraventricular extrosystole (SVE)	124.52 ± 10.3	111.6 ± 9.2	101.4 ± 8.2	96.5 ± 6.7
Coupled and group SVE	63.4 ± 5.3	64.1 ± 4.5	23.5 ± 3.1**	26.6 ± 2.3**
Single VE	106.8 ± 13.1	98.3 ± 10.1	63.5 ± 7.6*	56.7 ± 6.8*
Coupled VE	12.6 ± 1.4	7.4 ± 1.1	4.6 ± 2.3*	2.8 ± 1.1*
ST segment elevation)	0.69 ± 0.04	0.65 ± 0.03	0.61 ± 0.03	0.59 ± 0.02
QT (msec)	414.3 ± 28.9	408.3 ± 31.2	411.3 ± 26.4	408.1 ± 27.6

*Note: *– $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$*

As shown in table 5, the maximum and average heartbeats, and single and coupled ventricular extrasystoles in men living in urban conditions are reliably reduced (p<0.05) under the influence of dosed walking and physical activity in combination with standard treatment measures carried out in patients with CAD, coupled and group supraventricular extrasystoles decrease in both sexes at a highly reliable level (p<0.01). All patients tend positive changes in ST segment changes, ventricular extrasystoles.

Table 6. *Results of initial and 6-month follow-up Holter monitoring of rural patients with CAD*

Indicator	Initial		After 6 months	
	Males (n=51)	Females (n=43)	Males (n=51)	Females (n=43)
Max. Heart beat	116.9 ± 10.2	131.3 ± 11.6	95.4 ± 8.8	105.4 ± 9.7
Min. Heart beat	54.5 ± 5.3	61.3 ± 5.8	51.6 ± 5.9	54.6 ± 4.1
Average heart beat	68.7 ± 7.1	78.3 ± 6.1	62.4 ± 4.7	64.5 ± 5.2
Single SVE	258.8 ± 33.4	239.6 ± 38.7	143.8 ± 12.7*	121.5 ± 14.5*
Coupled and group SVE	77.6 ± 6.5	65.8 ± 7.8	45.9 ± 5.3*	37.9 ± 4.1*
Single VE	145.7 ± 11.7	118.3 ± 12.7	101.7 ± 10.1*	74.7 ± 8.6*
Coupled VE	17.1 ± 2.4	13.4 ± 1.3	4.8 ± 0.9**	3.6 ± 0.7*
Changes of ST segment	0.64 ± 0.03	0.67 ± 0.03	0.60 ± 0.03	0.61 ± 0.02
QT (msec)	421.0 ± 24.7	419.3 ± 34.9	418.0 ± 21.3	417.6 ± 37.5

*Note: * – $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$*

Table 6 shows that the number of single, coupled and group supraventricular extrasystoles in men who live in rural areas decreased significantly under the influence of a dosed walking and physical activity program, which was carried out continuously in combination with standard treatment measures, (p<0.05), the number of single and coupled ventricular extrasystole decreased at a highly reliable level (P<0.01), there is a tendency to decrease the maximum, minimum and average heart beats.

In female patients living in rural areas, single, coupled, and group ventricular extrasystoles, single and coupled ventricular extrasystoles have decreased dramatically (p<0.05), and there is a tendency to decrease maximum, average, and minimum heartbeats. All patients tend positive changes in ST-segment change.

In **conclusion**, it can be said that, in addition to the standard treatment of patients with CAD, continuous physical activity, regardless of living conditions, has a positive effect on the amount of atherogenic and antiatherogenic lipoproteins, the number of heart contractions, supraventricular and ventricular arrhythmias.

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submitted 16.08.2024;
accepted for publication 31.08.2024;
published 28.09.2024

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