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Physical Activity and Ischemic Stroke Prevention

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Abstract

Introduction:

Ischemic stroke is one of the most common cerebrovascular diseases, a leading cause of disability, and the primary cause of death globally. Numerous risk factors for stroke can be eliminated or mitigated through proper health-promoting measures, with regular physical activity being one of the most crucial. Exercise directly and indirectly reduces stroke risk by enhancing cardiovascular health and mitigating other risk factors.

Aim of the study:

This analysis is based on a review of studies and information found in the PubMed and Google Scholar databases regarding the impact of sports on the risk factors for ischemic stroke.

Conclusions:

The literature review indicates that sport has a direct effect on reducing the risk of ischemic stroke, but also an indirect effect in minimizing the risk factors for ischemic stroke. The existing research results have recorded a significantly beneficial impact of sport, such as the reduction of atherosclerotic changes in vessels, lowering blood pressure, and improving the elasticity of blood vessels.

Keywords: Stroke, ischemic stroke, risk factors, prevention of stroke, sport

Introduction

According to the World Health Organization (WHO), stroke is a clinical syndrome characterized by the sudden onset of focal or generalized brain dysfunction that lasts longer than 24 hours (or results in death within this period) and has no other cause than vascular origin [1]. Each year, 15 million people globally experience a stroke, and 5.5 millions of these cases result in death. In Poland, the incidence rate of stroke is 175 per 100,000 among men and 125 per 100,000 among women [2]. Many risk factors for stroke have been identified, the most significant being hypertension and physical activity. Regular physical activity has a beneficial effect on the cardiovascular system by inducing adaptive changes that improve its efficiency. It also indirectly reduces other risk factors, such as cardiovascular diseases, obesity, dyslipidemia, and hypertension, making it a crucial preventive measure against stroke.

AIM OF THE STUDY

The study aims to assess the impact of physical activity on reducing the risk of ischemic stroke by analyzing physiological mechanisms supporting cardiovascular function and regulating stroke risk factors such as obesity, dyslipidemia, diabetes, and hypertension.

MATERIALS AND METHODOLOGY

The analysis was conducted based on a thorough review of studies and data related to stroke, using the PubMed and Google Scholar databases. Keywords such as "stroke," "ischemic stroke," and "physical activity" were used during the search. Additionally, relevant clinical studies were included to provide a comprehensive perspective on the topic.

Ischemic Stroke Pathogenesis:

Ischemic stroke, which accounts for approximately 85% of all strokes, occurs due to the narrowing or complete blockage of one of the brain-supplying arteries. Blood flow reduction or cessation may result from a thrombus forming on a ruptured or ulcerated atherosclerotic plaque. An embolic event may also cause this type of stroke, with emboli often originating from the left heart. These emboli can also consist of cancer cells, fat, or air. [8]

Brain ischemia can be localized or generalized, and the effects of a stroke depend on the severity and duration of ischemia. Neurons, which are the most sensitive to ischemia, are the first to suffer damage. The ischemic focus resulting from arterial occlusion can be divided into a central core and a penumbra. The central core, due to the lack of collateral circulation, undergoes necrosis, while the penumbra, the area surrounding the necrotic core, retains impaired but viable neuronal activity. Restoring blood flow to the penumbra area as quickly as possible is critical to preventing neuronal death. Thus, timely diagnostic and therapeutic interventions are vital in stroke management. Given the high prevalence of ischemic stroke and its severe complications, knowledge of general symptoms is crucial for early detection and response, significantly reducing associated complications. [3].

Symptomatology of Ischemic Stroke:

The symptoms of ischemic stroke depend on its underlying mechanism and the affected arterial territory. In thrombotic strokes, symptoms may develop acutely, but prodromal symptoms often precede the event by several hours or days in three-quarters of cases. In contrast, embolic strokes typically present suddenly without warning signs.

Early symptoms of stroke include speech disturbances, facial asymmetry (e.g., drooping of the mouth or eye corner), and limb weakness. More specific symptoms depend on the affected arterial supply, which can be classified into anterior (internal carotid artery) and posterior (vertebrobasilar system) circulations.

Disruption in anterior circulation may manifest as hemiparesis, hemisensory loss, aphasia, neglect, monocular vision disturbances, or even pseudobulbar dysphagia. Posterior circulation issues may present with dizziness, nausea, vomiting, tinnitus, hearing impairment, diplopia, scotomas, balance-related gait disturbances, or sudden falls (drop attacks) [5].

Stroke Diagnosis:

Diagnosing stroke is not solely based on clinical symptoms or neurological examinations, as many other conditions can mimic stroke. Stroke diagnosis integrates clinical assessment with additional diagnostic techniques.

Diagnostic methods include non-contrast computed tomography (CT), Doppler ultrasound of the head and neck arteries, magnetic resonance imaging (MRI), angiographic studies, cardiac examinations (ECG, echocardiography), electroencephalography, and laboratory tests. Although no specific laboratory tests definitively diagnose stroke, they provide essential insights into potential underlying causes, such as coagulation profile abnormalities, lipidogram deviations, or autoimmune markers (e.g., antiphospholipid antibodies) [21].

The Use of Computed Tomography in Ischemic Stroke

The most important and primary diagnostic test for ischemic stroke is computed tomography (CT). A non-contrast head CT scan is routinely employed to diagnose the early phase of a stroke. It is also the sole radiological examination required to qualify a patient for thrombolytic therapy, as it can promptly detect acute intracranial hemorrhage, which is one of the primary contraindications for thrombolysis (Figure 1).

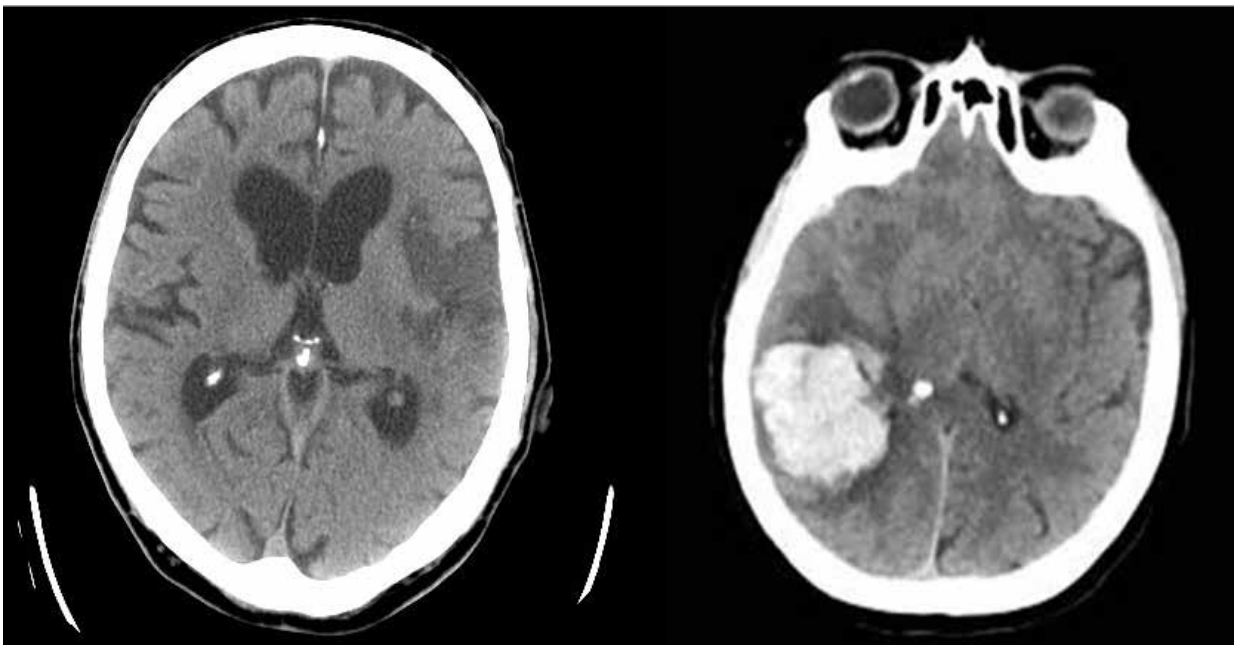

Figure 1. Ischemic lesion in the left hemisphere (A) and hemorrhagic lesion in the right hemisphere (B) on a head CT scan [9].

CT is a non-invasive, quick, and cost-effective examination with broad availability. Despite these advantages, it has certain limitations. Early ischemic changes in CT images can be subtle, and ischemic lesions in the cerebellum and brainstem are less visible due to surrounding bony structures. Consequently, accurate stroke diagnosis in such cases depends on the radiologist's experience (Figure 2) [9]. The issue of subtle and delayed changes in CT imaging arises from the fact that the sensitivity of CT varies significantly across different stroke phases. It is notably the lowest during the hyperacute phase (< 6 hours) but increases significantly as the infarction area becomes more organized over time [12]. This is because, during the ąhyperacute phase, cytotoxic edema in the brain does not affect image density, and changes only become visible with the onset of vasogenic edema and mass effect [10, 11].

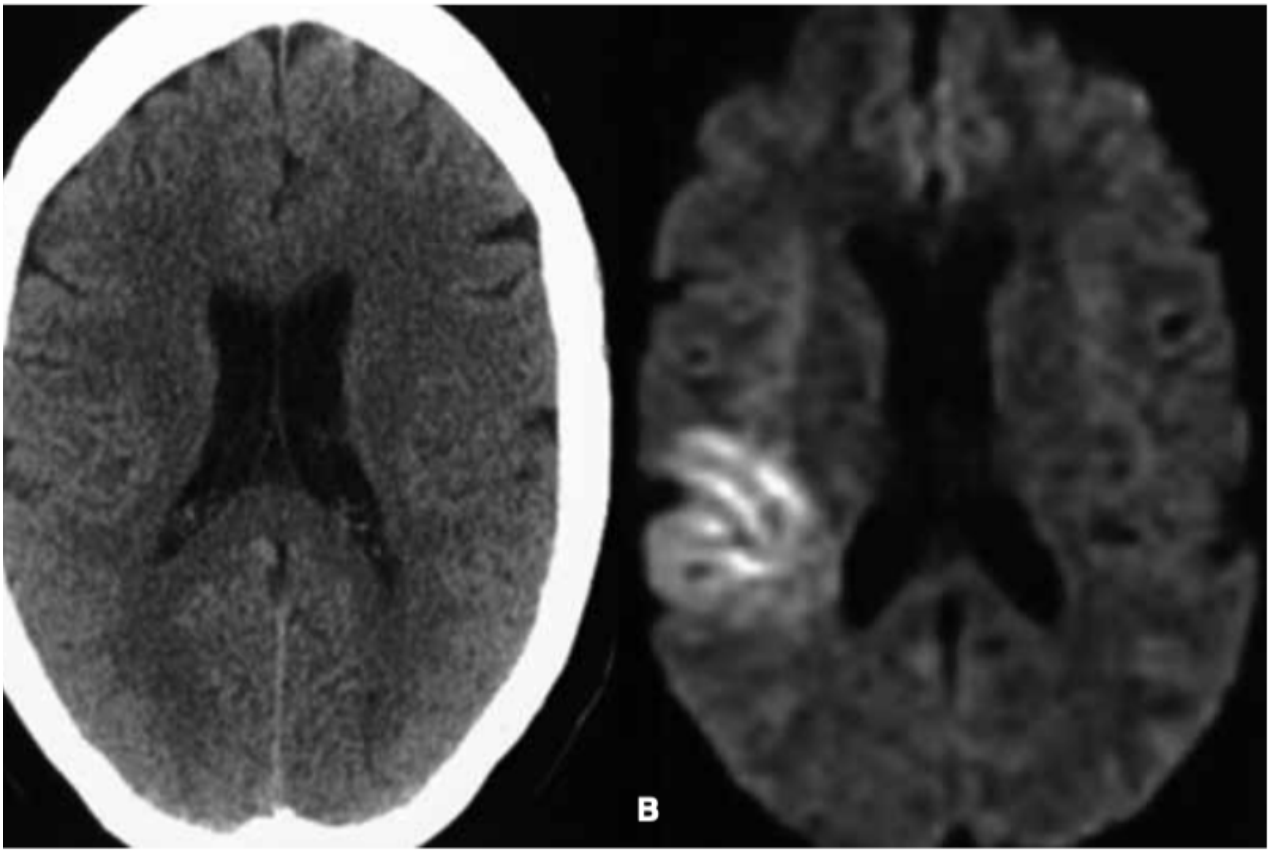

Figure 2. Ischemic stroke — hyperacute phase. Comparison of CT vs. MRI DWI performed within 8 hours of symptom onset: A. CT scan shows no ischemic area; B. MRI DWI reveals a hyperintense area [9].

Limitations of Non-Contrast CT in Early Ischemic Stroke Detection

Non-contrast CT can detect ischemic changes relatively late, usually about six hours after the onset of neurological symptoms. However, earlier (within 2–3 hours), extensive ischemic areas may be visualized. Such findings are prognostically unfavorable, as they are often associated with a dynamic disease course leading to severe neurological deficits or even death [13, 14, 15].

Early CT changes in ischemic stroke include cortical sulcal effacement, decreased differentiation between gray and white matter in the ischemic area due to mass effect, displacement of brain structures, and visible hyperdense arteries responsible for the ischemia (Figure 3). The hyperdensity results from thrombotic material within the vessel. Over time, CT changes manifest as hypodense areas relative to healthy brain tissue. The difference in attenuation coefficients typically ranges from 10–30 HU (Hounsfield Units) (Figure 4) [10].

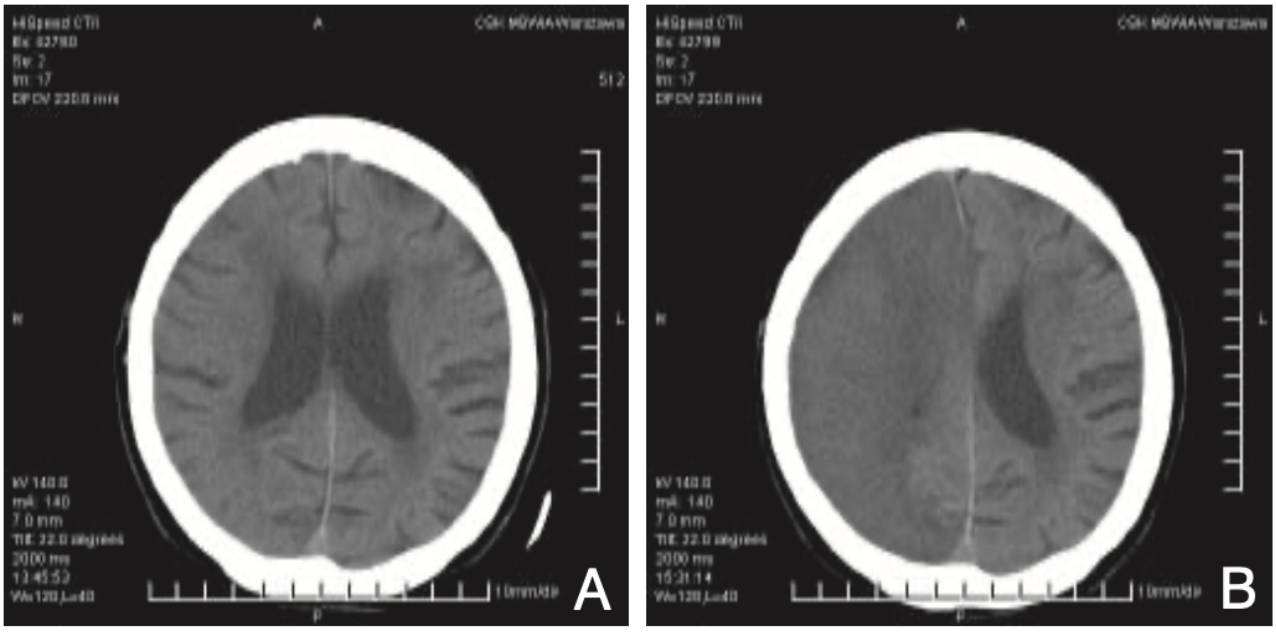

Figure 3. CT scan of a 79-year-old patient with stroke symptoms lasting 2 hours: A. Blurring of deep structures; B. Hyperdense middle cerebral artery [12].

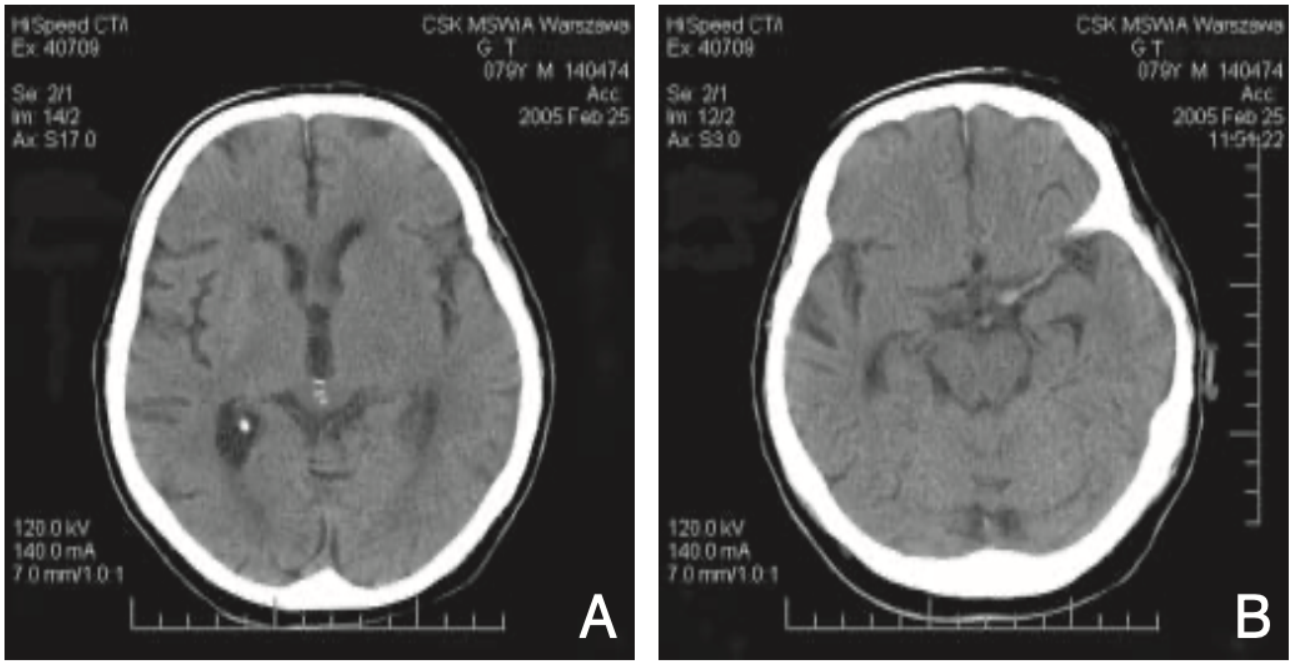

Figure 4. A 55-year-old patient with left-sided hemiparesis. A. CT scan at 2 hours post-symptom onset shows no changes; B. By the third day, CT reveals a hypodense area encompassing nearly the entire right hemisphere, with a faint mass effect [12].

Risk Factors and Stroke

A significant issue in the context of ischemic stroke is the presence of risk factors, which markedly increase the probability of a stroke due to their influence on pre-existing vascular changes or the formation of new, independent alterations. These factors are divided into non-modifiable and modifiable.

Non-modifiable risk factors include:

- **Age**: In individuals >55 years, the risk of stroke doubles due to the progression of atherosclerosis with age.
- **Gender**: Men are at a higher risk until the age of 65, after which this trend reverses, with women becoming more vulnerable.
- **Genetic factors**: The presence of certain genetic disorders predisposes individuals to stroke even at a young age, such as hypercoagulopathy or hypercholesterolemia.
- **Previous stroke**: Studies indicate that within 30 days of the first stroke, 3.4% of patients experience another; within one year, approximately 14%; and within five years, as many as 30–40%.

Hypertension is the most important modifiable risk factor. It is a risk factor for both ischemic and hemorrhagic stroke. It is estimated that hypertension coexists in only one-third of patients with stroke. Studies have proven that the higher the blood pressure, the greater the risk of both ischemic and hemorrhagic stroke. Hypertension increases the risk of ischemic stroke 4–5 times and hemorrhagic stroke as much as 9 times. Lowering systolic blood pressure reduces stroke risk regardless of the patient's age [3]. Additionally, hypertension accelerates the process of atherosclerosis.

Atrial fibrillation is also a modifiable risk factor. As the most common atrial tachyarrhythmia, it is the most widespread cause of embolisms in cerebral circulation and, consequently, ischemic stroke. This risk is as much as 5–6 times higher than in the general population with sinus rhythm, and it is independent of whether atrial fibrillation is paroxysmal or persistent [3].

Acute coronary syndrome, due to complications such as dyskinesia/akinesia of the anterior wall, interventricular septal aneurysm, or left ventricular dysfunction, which create a risk of thrombus formation in the left ventricle, is a modifiable risk factor [3,17].

Diabetes is a treatable risk factor for stroke. This is related to the fact that chronic hyperglycemia accelerates atherosclerosis through structural changes in vessel walls and increases the risk of thrombosis. Additionally, diabetes leads to elevated levels of fibrinogen and von Willebrand factor, which have pro-thrombotic effects. Co-occurring dyslipidemia in diabetes inhibits the fibrinolysis process, which altogether contributes to the occurrence of stroke.

Lipid metabolism disorders significantly contribute both directly and indirectly to stroke. Hypercholesterolemia, high LDL cholesterol levels, and low HDL cholesterol levels strongly correlate with myocardial infarction and exceptionally strongly influence the progression of atherosclerosis, which plays a crucial role in stroke pathogenesis.

Another modifiable risk factor is hyperhomocysteinemia. Excess homocysteine exerts cytotoxic effects on the vascular endothelium, promoting thrombotic changes, particularly in younger individuals.

Oral contraceptives and hormone replacement therapy constitute another risk factor for stroke by increasing estrogen levels, which have pro-thrombotic effects.

Great importance in stroke prevention is placed on lifestyle changes in patients. Lifestyle-related risk factors include smoking, excessive alcohol consumption, unhealthy diet, obesity, and insufficient or lack of physical activity. These factors indirectly affect the other modifiable risk factors mentioned above. Additionally, a study conducted in 2002 at the Adult Neurology

Clinic of the Medical University of Gdańsk demonstrated that among 100 patients with a history of stroke, lack of physical activity was the second most frequent risk factor for stroke, following hypertension. This study highlights the critical role of physical activity in preventing ischemic stroke [6].

Physical Activity and Its Impact on Health

Physical activity is one of the most important elements of a healthy lifestyle and a key determinant of physical and mental health. A breakthrough in the search for non-medical determinants of health was Lalonde's health fields concept. This concept demonstrates that the greatest influence on an individual's health is their lifestyle and health-promoting behaviours, among which physical activity plays a significant role.

The World Health Organization (WHO), based on extensive data, has identified insufficient physical activity as the fourth most common risk factor for premature death and global mortality. The benefits of regular physical activity are reflected in numerous scientific studies. These studies show the beneficial effects of physical exercise on both physical and mental health. Regular exercise plays a crucial role in the primary and secondary prevention of many diseases and conditions.

The main advantages of physical exercise include maintaining a healthy body weight, combating obesity, and reducing the risk of developing hypertension, coronary artery disease, heart attack, and diabetes. Additionally, exercise has been shown to have positive effects on bone health and processes related to cancer prevention.

In terms of mental health, physical activity helps manage stress, reduces psychological tension, and improves mood and self-esteem. These benefits make physical activity a vital factor in shaping health, developing habits, and fostering other health-promoting behaviors. Conversely, a sedentary lifestyle has serious health consequences and contributes to the development of pathological changes.

In light of this, WHO has established recommendations for physical activity. The World Health Organization recommends:

- **Children and adolescents**: 60 minutes of daily physical activity.
- **Adults**: 30 minutes of moderate-intensity physical activity daily to improve muscle strength and endurance.
- **Seniors**: 30 minutes of activity focused on improving motor coordination.

These guidelines underscore the importance of regular physical activity in promoting health and preventing disease.

Physical Activity – Its Role in Ischemic Stroke

In the context of ischemic stroke, physical activity is considered one of the key preventive measures. Regular physical activity has both direct and indirect benefits. It improves the elasticity of blood vessels, enhances brain neuroplasticity—which supports the growth and regeneration of neurons and improves the brain's adaptive abilities even during ischemia—and increases cerebral blood flow, leading to better oxygen and nutrient delivery to the brain, thereby reducing the risk of ischemia. Additionally, physical activity exerts multifaceted anticoagulant and anti-inflammatory effects, lowers serum homocysteine levels, and indirectly mitigates other significant risk factors for stroke, such as obesity, dyslipidemia, hypertension, and cardiovascular diseases【7,29,30】.

Physical activity induces numerous positive changes in the body. Regular exercise increases energy expenditure, and when this energy is not replenished through food (creating an energy deficit), adaptive mechanisms are activated. The body begins to use stored energy, such as fats, leading to the breakdown of adipose tissue and, consequently, weight loss【22】.

In terms of dyslipidemia, physical activity also plays a significant role. Numerous studies have demonstrated its positive impact on reducing triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C) levels while increasing high-density lipoprotein cholesterol (HDL-C) levels. Combining regular physical activity with a low-cholesterol diet can reduce total cholesterol by up to 10%, triglycerides by 24%, and increase HDL cholesterol by as much as 3%【22–26】. These findings also suggest that physical activity, coupled with a healthy diet, can slow the progression of atherosclerotic changes in blood vessels, reducing the risk of coronary artery disease and heart attack【27】.

Regular exercise has also been shown to prevent the development of insulin resistance and improve carbohydrate metabolism【31】. However, the best-documented benefit of physical activity pertains to one of the primary stroke risk factors: hypertension. The mechanism by which physical activity lowers blood pressure includes reduced levels of norepinephrine, increased nitric oxide production, and enhanced endothelium-dependent

vasodilation. These effects decrease peripheral resistance and reduce the afterload on the heart, leading to a drop in blood pressure.

Clinical studies have demonstrated significant reductions in blood pressure values with exercise. Aerobic exercise has been shown to reduce systolic blood pressure by 4.7 mmHg and diastolic blood pressure by 3.1 mmHg. This hypotensive effect is independent of exercise intensity, which ranged from 30–87% of VO_2max, or training frequency, which varied from 2–5 sessions per week【24】. Other studies have shown that endurance training can lead to average reductions in systolic blood pressure by 3.48 mmHg and diastolic blood pressure by 2.58 mmHg. These effects are observed in both hypertensive and healthy individuals and are independent of body weight【28】.

A reduction in diastolic blood pressure by 5 mmHg is associated with a 34% reduction in stroke incidence and a 21% decrease in coronary artery disease, which is also a risk factor for stroke. A further 10 mmHg reduction in diastolic blood pressure lowers stroke incidence by 56% and coronary artery disease by 37%【3】.

Discussion:

A stroke is a cerebrovascular disease caused by disruptions in blood flow to the brain for various reasons. If blood flow ceases due to an obstruction in cerebral vessels, the condition is termed an ischemic stroke. If caused by bleeding into the brain tissue, it is termed a hemorrhagic stroke. Both types result in oxygen deprivation of neurons, leading to impaired brain function [20]. Stroke is one of the most severe cerebrovascular diseases and represents a significant medical challenge due to its high prevalence, mortality rate, and the severe complications it causes, such as cognitive impairment, speech disorders, and physical disabilities. Most stroke survivors require assistance in daily life, prolonged rehabilitation, and incur substantial financial costs for both healthcare systems and patients [3].

Conclusions

Regular physical activity is a key element in the prevention of ischemic stroke. It enhances cardiovascular system functioning, supports weight control, and helps regulate blood pressure—factors directly linked to the risk of ischemic stroke. These findings highlight that physical activity alone can significantly reduce the risk of ischemic stroke.

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