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THE IMPACT OF PHYSICAL ACTIVITY ON VENOUS THROMBOEMBOLISM

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ABSTRACT

Venous thromboembolism (VTE), which consists of deep vein thrombosis (DVT) and pulmonary embolism (PE), is one of the most common cardiovascular diseases. Despite improvements in prevention, diagnosis, and treatment, its mortality rates are still high and remain a major problem in public health. The World Health Organization (WHO) recommends that adults (aged 18–64 years) engage in at least 150–300 minutes of moderate-intensity aerobic physical activity or 75–150 minutes of vigorous-intensity aerobic activity per week. Prolonged sedentary behavior contributes to increased venous compression in the lower extremities, leading to reduced venous return and an elevated risk of VTE. Many studies have observed a risk increase of up to 2-10% per additional hour of prolonged sitting. In the literature, a positive correlation was found between higher levels of PA and reduced risk of VTE, indicating a significant reduction in risk for those with higher levels of PA, even at levels below norms established by the WHO. However, some research indicates that the highest level of physical exertion—defined as regularly engaging in hard physical training (i.e., vigorous exercise or participation in competitive sports several times per week)—was associated with a twofold increased risk of first-time VTE. The aim of this review is to provide a general overview of the impact of physical activity on venous thromboembolism.
Material and method: A review of available literature from the PubMed database from 2005 to 2024.

KEYWORDS

Venous Thromboembolism, Physical Activity, Sedentary Behavior, Risks of Venous Thromboembolism

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Introduction

Venous thromboembolism (VTE), consisting of deep vein thrombosis (DVT) and pulmonary embolism (PE), is one of the most common cardiovascular diseases. The incidence of VTE is estimated at 1–2 cases per 1, 000 individuals annually [1], making it the third most common cardiovascular condition after myocardial infarction and stroke [2]. Despite advancements in prevention, diagnosis, and treatment, the mortality rate among patients with VTE remains high; up to 20% of individuals die within 1 year of a VTE diagnosis [3].

VTE may present as minimally symptomatic deep vein thrombosis or as massive, life-threatening pulmonary embolism. The standard treatment involves intravenous anticoagulant therapy, while in life-threatening cases, percutaneous catheter-directed interventions may be considered.

Risk factors for VTE can be categorized as modifiable and non-modifiable (Table 1). One of the most easily modifiable risk factors is physical activity. Although the relationship between physical activity and the prevalence of cardiovascular diseases is well established, its role in VTE, either protective or predisposing remains a subject of ongoing debate.

Table 1. Division of risk factors for VTE [4], [5].

Modifiable risk factors	Temporary risk factors	Non-modifiable risk factors
Obesity (BMI ≥30 kg/m2) Immobility due to sitting Oral contraceptive therapy Hormone replacement therapy (depends on formulation) Physical activity Diabetes mellitus Arterial hypertension Varicose veins	Hospitalization for heart failure or atrial fibrillation/flutter (within previous 3 months) Myocardial infarction (within previous 3 months) Hip or knee replacement Major trauma Blood transfusion Pregnancy and post-partum period Cancer (highest risk in metastatic disease) Infection (specifically pneumonia and urinary tract infection) Erythropoiesis-stimulating agents Bed rest >3 days Prolonged car or air travel	Previous VTE Age (≥70 years) Thrombophilia (deficiency of antithrombin, protein C or S, factor V Leiden, G20210A prothrombin gene mutation, or antiphospholipid syndrome) Autoimmune diseases Infection (HIV) Inflammatory bowel disease Superficial vein thrombosis

Role of physical activity

Physical activity is a key protective factor against numerous common diseases within the general population. Regular exercise reduces the risk of hypertension, type 2 diabetes, cancer, and all-cause mortality, and has a beneficial impact on mental health [6].

The World Health Organization (WHO) recommends that adults (aged 18–64 years) and older adults (aged 65 years and above) engage in at least 150–300 minutes of moderate-intensity aerobic physical activity per week or 75–150 minutes of vigorous-intensity aerobic activity [6]. The guidelines emphasize that any level of physical activity is better than none and provides health benefits.

To assess the amount and intensity of physical activity, we can use both subjective (e.g., questionnaires) and objective methods (e.g., pedometers, accelerometers, indirect and direct calorimetry, fitness tests) [7], [8]. Objective methods allow more precise comparisons between participants and better capture variability in physical activity within individuals and are generally preferred.

Sedentary behavior and risk of VTE

A sedentary lifestyle represents a significant public health concern in highly developed societies, particularly due to the widespread prevalence of office-based work. Prolonged periods of physical inactivity or minimal movement contribute to increased venous compression in the lower extremities, leading to reduced venous return and an elevated risk of venous thromboembolism (VTE). It is noteworthy that many individuals may meet the recommended levels of physical activity while still exhibiting high levels of sedentary behavior during the remainder of the day. Some scientific reports suggest that sedentary behavior may act as an independent risk factor for adverse health outcomes, separate from total physical activity.

Most studies indicate that sedentary behavior increases the risk of VTE. A linear dose–response relationship has been observed between sedentary time and VTE incidence, with approximately a 2% increase in VTE risk per additional hour of sedentary behavior per day [9]. Other studies report even higher estimates, with risk increases of 8–10% per additional hour of uninterrupted sitting [10], [11], [12]. Occupational computer use and leisure-time screen activities—particularly spending at least 10 hours per 24-hour period, with bouts lasting ≥2 hours without standing or movement—have been identified as risk behaviors [10]. The same study highlighted that having a personal desk at work and regularly eating meals at the workplace was associated with a twofold increase in the likelihood of experiencing a VTE event [10]. Furthermore, individuals who reported”very often” watching television or streaming services during leisure time had a 1.71-fold higher risk of VTE compared to those who reported”never or seldom” engaging in such behavior [13].

Conversely, some studies have not confirmed a statistical association between sedentary occupational activity—defined as sitting for ≥6.5 hours per workday—and increased VTE risk [14]. The authors of this study suggest that the elevated risk observed in other investigations may be attributable to the quantity of prolonged sitting within a sedentary occupation, which increases the risk of VTE.

Positive impact of physical activity on VTE

The positive impact of physical activity (PA) on venous thromboembolism (VTE) is well-documented, highlighting its role in reducing the risk of this serious condition. Higher levels of PA are usually associated with a decreased risk of first-time VTE and are independent of demographic and health factors [15]. The association between PA and VTE is nonlinear, suggesting that even modest increases in activity can significantly decrease VTE risk.

A meta-analysis found that higher levels of PA were associated with a reduced risk of VTE, indicating a significant risk reduction was observed for those with higher levels of PA compared to those with lower levels [16]. However, the exact relationship between the optimal intensity, frequency, and duration of physical activity for VTE prevention remains unclear. It's important to note that while physical activity positively impacts initial VTE risk, it does not influence the risk of recurrent VTE.

A nonlinear association between PA and VTE was identified, with a steeper risk reduction of VTE even at levels below the norms established by the World Health Organization (WHO) [9]. The authors point out that if the population achieved half the recommended volume (75 min/week of moderate to vigorous PA), then 2.37% of VTE cases would potentially have been prevented. The observed relationships demonstrate the potential advantages of initially starting with small quantities of PA and progressively increasing over time.

In a population-based cohort study based on participants attending one or more surveys of Tromsø Study 4–6, PA was linked with a lower risk of VTE than being inactive [17]. The effect was particularly significant for provoked events and for those aged 65 years or older. In the elderly group, active individuals had a 30%

lower VTE risk than those who were inactive, and 12.5% of VTE incidents could be related to inactivity. The correlation occurred at a lower weekly amount of PA and was only partially mediated by BMI.

The research based on data from National Research Infrastructure SIMPLER (Swedish Infrastructure for Medical Population-based Life-course Environmental Research) found that a high level of PA was correlated with a lower risk of VTE in both female and male participants [18]. No detrimental influence of PA on VTE was revealed. Importantly, the study observed that the protective effect of PA appeared to be more pronounced in women than in men and showed a greater effect for VTE compared to PE.

A cohort study found a significant connection between increased PA and a lower risk of first-time VTE in the female population [19]. Women engaging in recreational PA at least once a week, as well as those with high occupational physical activity demonstrated a lower risk of first-time VTE in comparison to women with less or no PA. There was no statistically relevant association between different measures of PA and the risk of VTE.

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Negative impact of physical activity on VTE

The relationship between high physical activity (PA) levels and the risk of venous thromboembolism (VTE) is complex and somewhat contradictory across studies. While some research indicates a protective effect, others suggest. High PA levels may increase VTE risk.

The Uppsala Longitudinal Study of Adult Men reported that the highest level of physical exertion—defined as regularly engaging in hard physical training (i.e., vigorous exercise or participation in competitive sports several times per week)—was associated with a twofold increased risk of first-time venous thromboembolism (VTE) [20]. When additional cardiovascular risk factors (systolic blood pressure, LDL and HDL cholesterol levels, body mass index, diabetes, and smoking) were taken into account, the association became even more pronounced.

These findings are consistent with results from earlier systematic reviews, which reported that in some studies, the highest levels of physical activity were associated with an increased risk of VTE [21]. One such

study observed that more frequent and intense exercise was correlated with a higher incidence of VTE events [2]. Notably, the increased risk was particularly evident for provoked VTE.

A meta-analysis revealed a curvilinear dose-response relationship, suggesting that while moderate PA reduces VTE risk, excessive PA may inversely affect it, highlighting the need for optimal PA levels [9]. One of the reviews also noted that high PA levels could lead to increased risk due to potential physiological stressors associated with strenuous activities [15].

There are potential mechanisms for the possible correlation between strenuous physical activity (PA) and the incidence of venous thromboembolism (VTE) [18]. One of the propositions, grounded in previous investigations and supported by review articles, is that exercise sessions characterized by prolonged and intense exertion are correlated with an imbalance between pro-thrombotic and fibrinolytic factors, thereby precipitating a state of hypercoagulability alongside diminished fibrinolysis [18–21], as the levels of procoagulant parameters persist at elevated levels for a more extended duration compared to the quicker normalization of fibrinolytic parameters. Moreover, strenuous exercise appears to exert a more significant influence on platelet functionality in males, which may explain the elevated VTE risk observed in this demographic [20]. Another potential mechanism is increased blood viscosity caused by dehydration during physical exercise. Higher blood component concentration promotes clot formation in veins [22, 23]. Furthermore, strenuous exercise may induce microtrauma to the vascular endothelium, resulting in endothelial damage that could trigger thrombus development [24]. Lastly, aging is an established risk factor that escalates the likelihood of VTE [25].

While high exercise levels may increase VTE risk, moderate PA is repeatedly associated with a reduction of first-time VTE events. This association is important for understanding the optimal balance of activity levels for cardiovascular health.

VTE incidents in athletes

VTE incidents in athletes are relatively rare but present prominent health risks and are gaining more recognition within the athletic and sports community. They can occur even in young healthy sportsmen. Delayed diagnosis is a major problem because classical symptoms of VTE can be masked by sport-specific symptoms. [22], [23].

A review of 47 case reports of previously healthy, trained aerobic athletes who were diagnosed with VTE or PE following routine exercise found that oral contraceptives (OC) use was the most frequent risk factor reported in women, appearing in 14 of the 19 case studies involving females [23]. Furthermore, almost half of the cases indicated the presence of either a recent period of extended inactivity or an underlying genetic predisposition for thromboembolic disorders (in the majority of cases was documented as previously undiagnosed). A total of 32 of the 47 cases reported at least one of these three risk factors (OC use, a recent period of physical inactivity, or a hypercoagulable condition).

Another study evaluated 154 cases of VTE in athletes, identifying 89 cases of upper-extremity deep vein thrombosis (DVT), and 53 cases of lower-extremity DVT [22]. The upper-extremity DVT manifested mainly in male athletes engaged in strength training (especially weightlifters) and ball sports players (baseball). In 95% of DVT cases, the axillary-subclavian veins were affected. The anatomical constrictions of a thoracic outlet syndrome (TOS) (38%) and hereditary thrombophilia or a family history of VTE (16%) were identified as major causes of upper-extremity DVT. The lower extremity DVT is related primarily to endurance sports (running and marathons) and ball sports, mainly in men. The main accompanying factors were hereditary thrombophilia or a family history of VTE (30%) and trauma (25%). In both extremities, DVT OC use was also evaluated (7%/27% of women in upper-extremity DVT and 11%/21% of women).

The prevalence of VTE in athletes is a combination of genetic predispositions and lifestyle-related risks. Intense physical training may lead to concentration of blood components and increase the risk of thrombosis. Dehydration is common in athletes due to prolonged strain and often further intensifies hemoconcentration. [24]. Injuries or long-distance travel impose long periods of immobility in athletes. Immobility leads to venous stasis and slower blood flow, a key component that predisposes to VTE [22]. The use of oral contraceptives in female athletes, has been identified as a risk factor for VTE, contributing to hypercoagulability [23].

Physical activity after VTE incident

Physical activity after VTE is a topic of great interest due to its potential impact on recovery and prevention of further incidents.

Patients who went through the combination of early mobilization and compression therapy had removed edema quickly than those who were assigned to the bed rest group [27]. There was a significant difference in pain prevalence between the groups, in the compression and early mobilization group, pain was reduced to near baseline on day 3 after VTE incident.

Long term activity (1 month after VTE incident) was not associated with an increased risk of developing chronic pain and swelling in the next 2 years [28]. Patients who had developed PTS (post thrombotic syndrome) before 2 years follow-up tended to be less physically active (42.4% occurrence of moderate or severe PTS in none physical activity group. The Lakoski study observed no indications of recurrent DVT or PE at the 6-week mark in exercise group while individuals were receiving therapeutic anticoagulation, and there was also no difference in calf circumference between the exercise and control groups [26]. According to the cited research, patients 6 weeks from the acute VTE event were able to perform maximal exercise tolerance testing without chest pain, ischemic changes on ECG or exercise hypoxia (O2 saturation of < 92%). One of the papers found that while high physical activity levels reduce the risk of initial VTE, they do not influence the risk of recurrent VTE, and future investigation is suggested [15].

While the benefits of physical activity post-VTE are evident, the optimal type, intensity, and timing of physical activity remain areas for further research.

Conclusion

The connection between physical activity and venous thromboembolism (VTE) is a complex and difficult matter. Depending on the level and context of PA evidence suggests both protective and risk-enhancing roles of exercise. The relationship is not straightforward and varies with the intensity and type of activity. Regular physical activity is generally associated with a reduced risk of VTE, particularly for first-time events. On the other side, low PA and sedentary behavior are factors increasing the risk of VTE and lead to worse outcomes in pain control and swelling reduction.

Future studies are needed to further examine the connection between PA and VTE, especially its optimal time and intensity, to fully help patients.

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Disclosure statement

Author's contribution

Conceptualization, Aleksandra Piech, and Karolina Pasierb;
Methodology, Karol Poplicha, Piotr Sobkiewicz;
Software, Tomasz Ufniarski, Justyna Moszkowicz;
Check, Martyna Grodzińska, Maria Kleczkowska and Marta Jutrzenka;
Formal analysis, Bartłomiej Siuzdak, Marta Jutrzenka, Martyna Grodzińska;
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