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Management and Prevention of Deep Vein Thrombosis in Endurance Athletes: A Systematic Review

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Abstract
Background: Venous thromboembolism (VTE) may also occur in highly trained individuals. In endurance athletes, diagnosis may be challenging because symptoms can resemble sports injuries or overuse conditions, while management must account for return to training and the risk of bleeding during anticoagulation.
Aim: This review aimed to synthesise the evidence on the pathophysiology, risk factors, diagnosis, treatment, and prevention of deep vein thrombosis **(**DVT) in endurance athletes.
Materials and methods: The review was conducted and reported in accordance with PRISMA 2020. PubMed and Scopus were searched for English-language publications dated from 1 January 2016 to 12 July 2026.
Results: A total of 139 records were identified. After 19 duplicates had been removed, 120 titles and abstracts were screened. Nineteen reports underwent eligibility assessment; five were excluded and 14 were included in the narrative synthesis. The evidence consisted mainly of case reports and small observational studies. Sports-related exposures most frequently coexisted with anatomical, inherited, or acquired risk factors. Diagnosis and initial treatment did not differ substantially from management in the general population, whereas decisions regarding invasive treatment and return to sport required individualisation. No evidence was identified to support routine pharmacological thromboprophylaxis in all healthy athletes.
Conclusions: DVT in endurance athletes is a multifactorial event, and population-specific evidence remains limited. Early recognition, identification of reversible and anatomical risk factors, guideline-based treatment, and individualised plans for prevention and return to training are essential.

Keywords: deep vein thrombosis; venous thromboembolism; endurance athletes; anticoagulant therapy; thromboprophylaxis; return to sport.

1. Introduction

Venous thromboembolism (VTE) comprises deep vein thrombosis (DVT) and pulmonary embolism (PE). Although regular physical activity provides substantial cardiovascular benefits and may reduce the risk of VTE, a high level of fitness does not preclude thromboembolic disease [1,2].

In endurance athletes, the risk of DVT may arise from the interaction between training- and competition-related exposures and acquired, inherited, or anatomical risk factors. Exercise alone should not be regarded as a direct cause of thrombosis [1,2,3].

Diagnosis may be delayed in this population because limb pain, unilateral swelling, a sensation of tightness, and impaired performance may be attributed to injury or overuse [4,5,6].

The clinical importance of this problem stems primarily from the risk of overlooking potentially fatal PE rather than from a demonstrated high incidence of DVT in this population. A reliable incidence estimate specific to endurance athletes has not yet been established. The available literature consists mainly of case reports, small case series, observational studies, and expert recommendations, which limits firm epidemiological conclusions [1,2].

This review aimed to synthesise current evidence on the diagnosis and treatment of DVT, return to training and competition, and preventive measures in endurance athletes. This population was defined as individuals participating in sports dominated by prolonged aerobic exercise, including long-distance running, cycling, triathlon, long-distance swimming, rowing, and cross-country skiing.

2. Materials and Methods

The review was conducted in accordance with the PRISMA 2020 statement [7]. PubMed and Scopus were searched on 12 July 2026 for English-language publications dated from 1 January 2016 to the search date. Search terms relating to DVT, VTE, athletes, and endurance sports were combined.

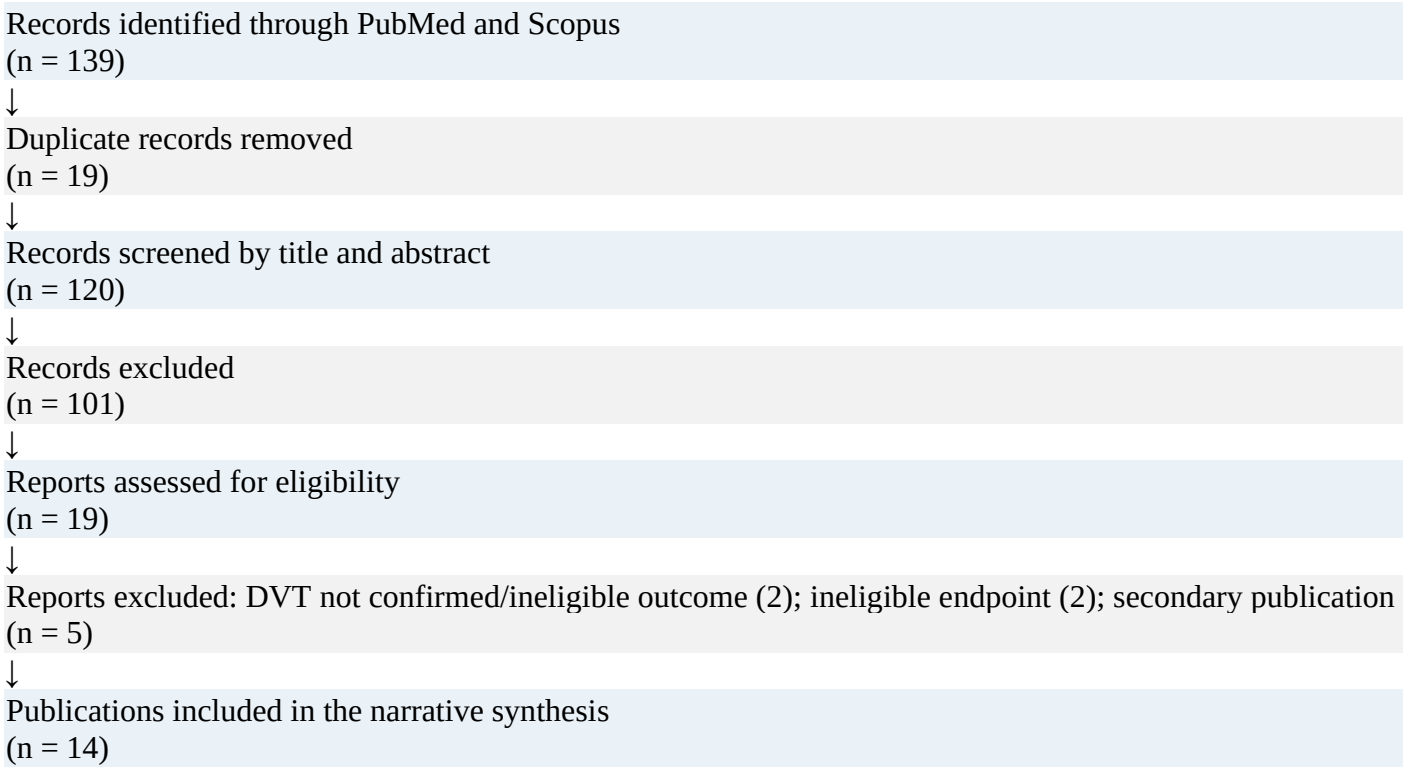
Studies of endurance athletes with confirmed DVT or VTE including DVT were eligible, as were prevention studies assessing surrogate markers associated with thrombotic risk in this population. Observational studies, case series, and case reports were included if they provided information on risk factors, diagnosis, treatment, prevention, or return to sport. Animal studies, publications unrelated to DVT/VTE or endurance sports, editorials, non-English-language papers, and articles published before 2016 were excluded. Reviews, guidelines, and studies conducted in other populations were used solely to provide clinical context and were not included in the primary synthesis of 14 publications.

After duplicates had been removed, two reviewers independently screened titles and abstracts and subsequently assessed reports eligible for further evaluation. Disagreements were resolved by consensus. Data were extracted on study design, sport, participant characteristics, DVT location, risk factors, diagnosis, treatment, prevention, and return to sport. When the full text was unavailable, information from the abstract was used. Owing to the predominance of case reports and substantial clinical heterogeneity, a narrative synthesis was undertaken without meta-analysis. No formal risk-of-bias assessment was performed.

3. Results

The search identified 139 records. After 19 duplicates had been removed, 120 titles and abstracts were screened, of which 101 were excluded. Of 19 reports assessed further, five did not meet the eligibility criteria: two because DVT was not confirmed or the outcome was ineligible, two because the endpoint was ineligible, and one because it was a secondary publication. Fourteen publications were included in the narrative synthesis (Figure 1).

Figure 1. PRISMA 2020 flow diagram



The evidence base consisted mainly of case reports involving runners, cyclists, triathletes, swimmers, and rowers [5,6,8,9,11,12,14,15,16,17,18]. It also included a cohort study of cross-country skiers [10], an analysis of the performance of the Wells score [4], and a study of haemostatic markers during air travel [13]. The most frequently reported events included upper-extremity thrombosis and lower-extremity thrombosis associated with iliac or popliteal venous compression [8,9,11,12,14,15,17,18].

In the case reports, sports-related exposures were usually accompanied by additional risk factors, including anatomical predisposition, thrombophilia, oestrogen-containing contraception, or other acquired clinical risk factors [5,8,9,11,12,14,17,18]. A study of 2,259 men found no significant association between recreational cross-country skiing and VTE risk [10]. Reports involving athletes suggested that VTE diagnosis may be delayed because of atypical symptoms or their attribution to sports-related conditions [5,6,16]. A separate analysis indicated that the Wells score may underestimate VTE probability in some athletes, although this finding has not been prospectively validated [4]. Anticoagulation was used in the reported patients, while catheter-directed thrombolysis, endovascular procedures, or surgical decompression were performed in selected situations [8,9,11,17,18]. Approaches to rehabilitation and return to sport varied, and no uniform return-to-sport criteria were identified [8,11,17,19].

Table 1. Characteristics of the publications included in the synthesis

Publication	Design and population	Location/diagnosis	Key findings
Blunt et al., 2023 [8]	Case report; elite female rower	Thrombosis of the subclavian, axillary, and superficial arm veins	Heterozygous factor V Leiden and venous compression; thrombolysis/thrombectomy, first-rib resection, and angioplasty; return to rowing after approximately 3 months.
Oh et al., 2023 [6]	Case report; 57-year-old Ironman triathlete	Multiple bilateral pulmonary emboli	Atypical symptoms and delayed diagnosis; the case highlights the need for clinical vigilance.
Petek et al., 2022 [9]	Case report; competitive cyclist	Lower-extremity DVT and compression of the right common iliac vein	Psoas muscle hypertrophy and homozygous factor V Leiden; enoxaparin followed by apixaban; limited effectiveness of angioplasty.
Kunutsor et al., 2021 [10]	Prospective cohort study; 2,259 men participating in	VTE during long-term follow-up	145 events over a median follow-up of 27.5 years; after adjustment for confounders, no significant

	recreational cross-country skiing		association was found between activity and VTE risk.
El-Attrache et al., 2020 [11]	Case report; 18-year-old swimmer	Paget–Schroetter syndrome	Imaging and treatment directed at upper-extremity effort thrombosis; clinical course and treatment outcome reported.
Kean et al., 2019 [12]	Case report; masters cyclist	DVT with suspected popliteal vein entrapment	Possible anatomical compression associated with cycling posture and load.
Taylor et al., 2018 [13]	Study of haemostatic markers; female Boston Marathon participants using oral contraceptives	No clinical DVT endpoint	The effect of compression stockings worn during a flight on haemostatic balance was evaluated; indirect evidence relevant to travel-related prevention.
Petrin et al., 2018 [14]	Case report; female runner	Lower-extremity DVT associated with May–Thurner syndrome	Unilateral painful thigh swelling associated with anatomical iliac vein compression.
Zaleski et al., 2017 [4]	Analysis of 11 case reports involving endurance athletes	DVT (n=6) and PE (n=5)	The Wells score did not identify cases in the analysed reports; the findings do not constitute prospective validation.
Sancho-Gonzalez et al., 2017 [15]	Case report; triathlete	Upper-extremity DVT	The case suggests an interaction between intense exercise and additional thrombotic risk factors.
Sanz de la Garza et al., 2017 [16]	Case report; marathon runner	Multiple pulmonary emboli	Atypical presentation of VTE in an endurance athlete; importance of early differential diagnosis.
Edo Fleta et al., 2016 [17]	Case report; 38-year-old female swimmer	Paget–Schroetter syndrome	Catheter-directed thrombolysis, 3 months of anticoagulation, rehabilitation, and a compression sleeve without surgery; asymptomatic at 6 months.

Suwal et al., 2022 [18]	Case report; young swimmer	Basilic, axillary, and subclavian vein thrombosis in Paget–Schroetter syndrome	Compression ultrasonography, duplex imaging, and venography; enoxaparin and referral for further intervention.
LeBlanc et al., 2021 [5]	Case report; 40-year-old female marathon runner	Calf DVT and cerebral venous sinus thrombosis	Oral contraception, Lynch syndrome, previous colorectal cancer, and a history of pregnancy; heparin treatment and discontinuation of oestrogen therapy.

4. Pathophysiology and Risk Factors for DVT in Endurance Athletes

The pathophysiology of DVT in endurance athletes is multifactorial and can be considered in relation to Virchow's triad: venous stasis, hypercoagulability, and endothelial injury [1,2]. Venous stasis may occur during prolonged travel to competitions, immobilisation after injury, or postoperative recovery [1,2]. Sustained sport-specific positioning and repetitive movement may additionally impair venous outflow through mechanical compression [3]. May–Thurner syndrome has been reported in runners [14], iliac or popliteal vein compression in cyclists [9,12], and Paget–Schroetter syndrome in swimmers and athletes performing repetitive upper-extremity movements [8,11,17,18].

Hypercoagulability may reflect both the physiological response to intense exercise and individual predisposition [1,2]. Exercise transiently activates coagulation, including increased factor VIII and von Willebrand factor activity and enhanced platelet reactivity [1,2]. Concurrent activation of fibrinolysis may counterbalance these procoagulant changes in healthy athletes [1,2]. Risk may increase in the presence of thrombophilia, antiphospholipid syndrome, oestrogen-containing contraception, malignancy, previous VTE, or anabolic-androgenic steroid use [1,2,5,8,9]. Dehydration and the associated haemoconcentration may further increase prothrombotic potential, although their independent clinical relevance has not been established conclusively [1,2].

Endothelial injury may result from sports -related trauma, surgery, repetitive microtrauma, or chronic venous compression [3]. Muscle hypertrophy and repetitive training movements may

cause local irritation of the vessel wall and impair blood flow [3,8,9]. This mechanism is particularly relevant to effort thrombosis of the upper extremity and anatomical venous compression syndromes [3,8,9].

Regular physical activity may reduce the overall risk of VTE; however, intense or prolonged exercise may transiently increase prothrombotic potential when additional risk factors are present [1,2].

5. Diagnosis and Management

Diagnosing DVT in endurance athletes may be challenging because pain, swelling, and limb tightness often resemble injury or overuse symptoms [4,5,19]. Particular concern should be raised by unilateral, progressive symptoms that are disproportionate to the apparent injury [4,5,19]. Unexplained dyspnoea, chest pain, tachycardia, syncope, or a sudden decline in exercise tolerance requires urgent investigation for PE [6,16,19].

Diagnostic assessment should begin with estimation of clinical probability [20]. An analysis of published reports suggested that the Wells score may underestimate VTE probability in some athletes; however, this finding has not been prospectively validated [4]. In patients with low or intermediate clinical probability, a normal D-dimer level can help exclude thrombosis, whereas an elevated result warrants imaging [20].

Compression ultrasonography with Doppler assessment is the first-line imaging test and has high sensitivity for proximal lower-extremity DVT in the general population [3,20]. If the result is negative or inconclusive but clinical suspicion persists, repeat ultrasonography should be considered [20]. Computed tomography or magnetic resonance venography may be useful when thrombosis has an atypical location or an anatomical obstruction to venous outflow is suspected [3,20].

Treatment should follow current VTE guidelines [20,21]. In most non-pregnant patients without contraindications, direct oral anticoagulants such as apixaban or rivaroxaban are preferred [20,21]. DVT associated with a transient risk factor is generally treated for at least three months [19,20,21]. The decision to extend therapy depends on the cause of thrombosis and the individual balance between recurrence and bleeding risks [19,20,21].

Routine thrombolytic or invasive treatment is not indicated for most patients [20,21]. It may, however, be considered in extensive iliofemoral thrombosis, severe symptoms, limb-threatening disease, or an anatomical obstruction to venous outflow [3,20,21]. In acute upper-extremity DVT associated with Paget–Schroetter syndrome, thrombolysis followed by surgical decompression may be considered in appropriately selected patients [3,8,11]. Thrombolysis is expected to be most effective within the first 14 days after symptom onset, although the supporting evidence remains limited [3].

Once effective anticoagulation has been initiated and clinical stability achieved, early graded mobilisation is recommended [3]. Return to sport should progress from activities of daily living and low-intensity exercise through moderate training to sport-specific loads [19]. During anticoagulation, activities carrying a substantial risk of falls, collision, or trauma should be restricted [2,19].

No single validated timeframe for safe return to full training has been established [2,19]. Decisions should be individualised according to clinical stability, the location and cause of DVT, response to treatment, recurrence and bleeding risks, the type of anticoagulation, and the characteristics of the sport [2,19]. Timeframes reported in reviews and individual reports should not be interpreted as universal recommendations [3,8].

6. Prevention of DVT in Endurance Athletes

Evidence on DVT prevention specifically in endurance athletes is limited and derives mainly from observational studies and reviews [1,2]. Some recommendations are therefore based on indirect evidence from travellers and patients with orthopaedic injuries or surgery [22,23,24]. Routine pharmacological thromboprophylaxis is not justified in all healthy athletes [2,22]. Assessment should account for previous VTE, thrombophilia, family history, oestrogen-containing contraception, injury, surgery, and the anticipated duration of reduced mobility [1,2,22].

Prolonged travel to training camps and competitions is particularly relevant [22]. In a review of 18 studies, an association between travel duration and VTE risk was observed from approximately four hours, and every additional two hours of air travel was associated with an approximately 26% relative increase in risk [22]. Absolute risk nevertheless remained low and

the quality of evidence was limited [22]. During travel, prolonged uninterrupted sitting should be avoided by walking periodically and regularly activating the calf muscles [22].

Properly fitted graduated compression stockings may be considered in travellers with additional VTE risk factors [22,23]. In a review of 12 randomised trials involving 2,918 passengers, asymptomatic DVT was detected in three individuals wearing stockings and 47 controls [23]. Compression stockings also reduced leg oedema [23]. No symptomatic DVT, PE, or deaths were recorded; consequently, their effect on these clinically important outcomes could not be established [23].

Injury, surgery, and limb immobilisation require reassessment of thrombotic risk [1,2,24]. In an indirect randomised study conducted outside the endurance-athlete population, which included 150 patients following surgical repair of Achilles tendon rupture, early mobilisation did not reduce DVT incidence compared with standard care [24]. Low limb loading, not exceeding 50% of body weight, was associated with a higher risk of thrombosis [24]. This suggests that actual weight-bearing and activation of the muscle pump may be more important than the recommendation to mobilise alone [24]. Indications for pharmacological prophylaxis after injury or surgery should be determined individually.

Additional measures include avoiding performance-enhancing substances with potential prothrombotic effects [1,2] and identifying biomechanical factors that promote repetitive venous compression [3]. Adequate fluid intake is reasonable during exercise and travel, but hydration alone has not been shown to prevent clinical DVT [1,2]. Prevention should therefore focus on identifying higher-risk athletes and reducing modifiable exposures associated with training, travel, injury, and recovery [1,2,22].

7. Discussion

This review indicates that DVT in endurance athletes should not be regarded as a direct consequence of training alone [1,2]. In the reported cases, sports-related exposures were generally accompanied by additional risk factors [5,8,9,14]. At the same time, the only large cohort study included in the synthesis found no increase in VTE risk associated with recreational cross-country skiing [10]. These findings argue against considering regular endurance activity an independent risk factor for thrombosis [1,2,10].

The principal clinical concern is delayed diagnosis [5,6]. Presentations of DVT or PE may initially be attributed to injury, overuse, or other sports-related conditions [4,5,6]. Moreover, standard clinical prediction rules have not been adequately validated in athletes [4]. Persistent unilateral symptoms, an abrupt decline in performance, or symptoms suggestive of PE should therefore lower the threshold for imaging, particularly when additional risk factors are present [19,20].

The principles of pharmacotherapy are consistent with recommendations for the general population [20,21]. Athlete-specific considerations chiefly involve the risk of injury during anticoagulation, recognition of venous compression syndromes, and planning return to training [2,3,19]. Thrombolytic and surgical interventions were used mainly for extensive DVT and upper-extremity effort thrombosis [8,9,11,17]; however, the available evidence does not permit comparison of their effectiveness with conservative treatment in a homogeneous athlete population [1,2,3].

Routine anticoagulant prophylaxis is not justified in healthy athletes [2,22]. The most appropriate strategy is individual risk assessment and reduction of modifiable exposures [22,23,24]. These recommendations should be interpreted cautiously because most have not been evaluated in interventional studies conducted specifically in endurance athletes [1,22,23,24].

8. Limitations

This review has several limitations. The evidence base was small and consisted predominantly of individual reports, which may disproportionately represent unusual or severe presentations and does not permit reliable estimation of DVT incidence or treatment effectiveness. Substantial heterogeneity in study populations, sports, thrombus locations, interventions, and reported outcomes precluded meta-analysis. The search was restricted to two databases and English-language publications, potentially resulting in the omission of relevant evidence, and the review protocol was not prospectively registered. Full texts were unavailable for seven of the 14 included publications; consequently, data extraction and verification of eligibility for these records were based on information reported in their abstracts. No formal risk-of-bias assessment was performed, which limits confidence in the findings and prevents a structured evaluation of methodological quality. In addition, some conclusions concerning prevention

were based on indirect evidence from populations other than endurance athletes. The search was completed on 12 July 2026 and therefore did not cover the entire 2026 calendar year.

9. Conclusions

DVT in endurance athletes has a multifactorial aetiology and generally develops through the interaction of sports-related exposures with inherited, acquired, or anatomical factors. Symptoms may mimic injury or overuse; consequently, persistent unilateral complaints and symptoms suggestive of PE require appropriate investigation. Initial management should follow current VTE guidelines, whereas invasive treatment, the duration of anticoagulation, and return to sport require individualisation. Prevention should focus on identifying higher-risk individuals and reducing modifiable exposures. Prospective studies are needed to evaluate recurrence, bleeding, and safe return to training.

Disclosure

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