



International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
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ARTICLE TITLE	PHYSICAL ACTIVITY AND DIGITAL HEALTH IN CHRONIC INFLAMMATORY DISEASES: STRATEGIES FOR CARDIOVASCULAR PREVENTION AND IMPROVED HEALTH OUTCOMES
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DOI	https://doi.org/10.31435/ijitss.3(51).2026.6370
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RECEIVED	27 May 2026
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ACCEPTED	15 September 2026
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PUBLISHED	23 September 2026
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PHYSICAL ACTIVITY AND DIGITAL HEALTH IN CHRONIC INFLAMMATORY DISEASES: STRATEGIES FOR CARDIOVASCULAR PREVENTION AND IMPROVED HEALTH OUTCOMES

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ABSTRACT

Background. Chronic inflammatory diseases are increasingly recognized as important contributors to cardiovascular morbidity and mortality. Persistent systemic inflammation, endothelial dysfunction, and accelerated atherosclerosis contribute to cardiovascular complications in autoimmune and chronic inflammatory disorders.

Aim. The aim of this review was to summarize current evidence regarding cardiovascular risk in selected chronic inflammatory diseases and to evaluate the role of physical activity as a non-pharmacological strategy influencing inflammatory and cardiovascular mechanisms. An additional aim was to explore how digital health technologies, including telemedicine and wearable devices, may support monitoring of physical activity and cardiovascular risk in these populations.

Materials and methods. A structured narrative literature review was conducted using PubMed, Scopus, and Google Scholar databases. Original studies, systematic reviews, meta-analyses, and clinical recommendations related to cardiovascular complications and exercise interventions were analyzed.

Results. The reviewed studies demonstrated a strong association between chronic inflammation, endothelial dysfunction, oxidative stress, and increased cardiovascular risk. Regular moderate-intensity physical activity was associated with reduced inflammatory burden and improved endothelial function. Emerging digital health tools, including wearable activity trackers and telemedicine platforms, showed potential to support remote monitoring of disease activity and exercise engagement, although their impact on hard cardiovascular outcomes remains insufficiently established. Exercise tolerance differed depending on disease severity and patient condition, particularly in long COVID patients.

Conclusions. Physical activity may support long-term management of chronic inflammatory diseases and contribute to cardiovascular risk reduction. Further studies are required to establish disease-specific exercise recommendations, and digital health solutions may facilitate their individualized, remote implementation.

KEYWORDS

Cardiovascular Disease, Chronic Inflammation, Physical Activity, Autoimmune Diseases, Digital Health, Wearable Devices

CITATION

Rak, Z., Wielogórska, A., Dzień, K., Sarek, F., Jóźwik, K., Kucharczyk, S., Ignatowska, Z., & Kamecki, A. (2026). Physical activity and digital health in chronic inflammatory diseases: Strategies for cardiovascular prevention and improved health outcomes. *International Journal of Innovative Technologies in Social Science*, 3(51). [https://doi.org/10.31435/ijitss.3\(51\).2026.6370](https://doi.org/10.31435/ijitss.3(51).2026.6370)

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1. Introduction

Cardiovascular disease (CVD) remains one of the leading causes of mortality worldwide despite major advances in prevention and treatment [1]. Traditional cardiovascular risk factors include hypertension, obesity, smoking and dyslipidemia. However, increasing evidence indicates that chronic inflammation itself contributes to vascular injury and accelerated atherosclerosis [2].

Several chronic inflammatory diseases, including systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), inflammatory bowel disease (IBD), psoriasis and long COVID, are associated with elevated cardiovascular risk [3,4]. Persistent immune activation, endothelial dysfunction and increased production of pro-inflammatory cytokines contribute to premature vascular aging and atherosclerotic progression [2,5]. Importantly, cardiovascular complications may develop even in younger patients without classical cardiovascular risk factors [3]. An additional clinical challenge is that cardiovascular abnormalities in chronic inflammatory diseases often remain subclinical for many years before overt cardiovascular events occur. In everyday practice, many patients present with persistent fatigue, exercise intolerance or reduced physical performance long before cardiovascular disease is formally diagnosed. This may delay implementation of preventive strategies and contribute to underestimation of long-term cardiovascular burden. Several authors have therefore emphasized the importance of early vascular assessment and broader cardiovascular monitoring in patients with chronic inflammatory disorders, especially in young individuals with prolonged inflammatory activity [34,35]. At the same time, the relationship between inflammation and cardiovascular disease appears to be bidirectional. Chronic inflammation may accelerate vascular injury, while metabolic abnormalities, sedentary behavior and reduced exercise tolerance may further intensify systemic inflammatory activation.

This complex interaction may partially explain why patients with autoimmune and inflammatory diseases frequently experience both progressive cardiovascular dysfunction and impaired quality of life [35].

Physical activity has gained increasing attention as a potential modulator of inflammatory and cardiovascular pathways [6]. Regular exercise is associated with improved endothelial function, reduced systemic inflammation and better metabolic regulation [6,7]. Exercise interventions may also improve physical capacity, fatigue and quality of life in patients with chronic inflammatory diseases [8].

In parallel, digital health technologies have become increasingly integrated into the management of chronic diseases. Wearable devices, mobile health applications and telemedicine platforms now allow continuous, remote assessment of physical activity, heart rate and disease activity, offering new opportunities for early identification of cardiovascular risk and for supporting exercise interventions outside traditional clinical settings [42,43]. At the same time, access to these technologies, as well as underlying cardiovascular risk itself, is shaped by social determinants of health such as socioeconomic status, digital literacy and healthcare access, which may widen or narrow existing health inequities among patients with chronic inflammatory diseases [46].

Most available studies focus on individual inflammatory diseases separately. Fewer reviews compare shared inflammatory mechanisms, cardiovascular consequences and exercise-related effects across different chronic inflammatory conditions.

The aim of this review was to summarize current evidence regarding cardiovascular risk in selected chronic inflammatory diseases and to discuss the role of physical activity as a supportive non-pharmacological strategy influencing inflammatory and cardiovascular pathways.

2. Methodology

This study was conducted as a structured narrative literature review examining the relationship between chronic inflammatory diseases, cardiovascular risk and the effects of physical activity on inflammatory and cardiovascular pathways.

Literature searches were performed using PubMed, Scopus and Google Scholar databases. The search strategy included combinations of the following keywords: “cardiovascular disease”, “cardiovascular risk”, “chronic inflammation”, “systemic lupus erythematosus”, “rheumatoid arthritis”, “psoriasis”, “inflammatory bowel disease”, “long COVID”, “physical activity”, “exercise”, “atherosclerosis”, “endothelial dysfunction”, “exercise tolerance”, “telemedicine”, “wearable devices”, “digital health” and “social determinants of health”.

The review primarily included studies published between 2018 and 2025 to ensure inclusion of current evidence regarding inflammatory mechanisms and exercise-related cardiovascular effects. Earlier studies were included when considered important for understanding cardiovascular pathophysiology and inflammatory mechanisms [2,19,20].

The analyzed literature included original research articles, cohort studies, systematic reviews, meta-analyses and clinical recommendations related to cardiovascular manifestations and exercise interventions in chronic inflammatory diseases. Particular attention was given to studies discussing endothelial dysfunction, inflammatory cytokines, accelerated atherosclerosis and exercise-related cardiovascular effects.

Studies unrelated to cardiovascular complications, inflammatory mechanisms or physical activity were excluded. Duplicate publications and articles with limited relevance to the topic were also excluded during the selection process.

After analysis of titles, abstracts and full-text articles, the selected studies were grouped into thematic categories including inflammatory mechanisms, endothelial dysfunction, cardiovascular manifestations, exercise-related effects and disease-specific cardiovascular findings.

Due to substantial heterogeneity between study populations, exercise protocols, cardiovascular outcomes and study designs, a structured narrative review approach was considered the most appropriate method for evidence synthesis. Preference was given to peer-reviewed studies published in English involving adult populations. Particular attention was directed toward studies evaluating endothelial function, inflammatory biomarkers, exercise tolerance and cardiovascular outcomes in chronic inflammatory diseases. When multiple studies addressed similar mechanisms, priority was given to larger cohort studies, systematic reviews and clinically relevant publications with broader translational implications. The literature selection process additionally focused on identifying studies describing practical exercise recommendations and limitations related to physical activity in patients with chronic inflammatory conditions. This approach allowed inclusion of both mechanistic and clinically applicable evidence regarding the relationship between physical activity, inflammation and cardiovascular risk.

3. Results

3.1. Chronic Inflammation and Endothelial Dysfunction

Chronic inflammation plays a central role in the development of endothelial dysfunction and premature atherosclerosis [2,5]. Persistent elevation of pro-inflammatory cytokines, particularly IL-6, TNF- α and IL-17, contributes to oxidative stress, impaired nitric oxide bioavailability and vascular injury.

Sattar et al. [2] described chronic systemic inflammation as a major factor accelerating vascular pathology in rheumatoid arthritis. Long-term exposure to inflammatory mediators may lead to endothelial damage, increased arterial stiffness and progression of atherosclerotic plaque formation. Similar mechanisms have been described in systemic lupus erythematosus, where cardiovascular complications often occur at a younger age than in the general population [3].

Roman & Salmon [3] reported that patients with autoimmune rheumatic diseases may develop subclinical atherosclerosis even in the absence of classical cardiovascular risk factors, supporting the concept that inflammation itself acts as an independent cardiovascular risk factor.

Inflammatory activation also affects lipid metabolism. Several studies suggested that chronic inflammation alters HDL function and promotes formation of pro-atherogenic lipid particles. Dysfunctional HDL may lose part of its anti-inflammatory and antioxidant properties, further contributing to endothelial injury and atherosclerotic progression [24,25].

Oxidative stress and mitochondrial dysfunction were also frequently associated with chronic inflammatory diseases. Increased production of reactive oxygen species contributes to vascular injury, impaired endothelial repair and arterial stiffness. Some studies suggested that these abnormalities may precede clinically detectable cardiovascular disease [24].

Aviña-Zubieta et al. [14] demonstrated increased cardiovascular mortality among patients with rheumatoid arthritis compared to the general population. Similarly, Bartels et al. [15] identified cardiovascular complications as one of the major causes of long-term morbidity and mortality in systemic lupus erythematosus despite improvements in disease management.

Endothelial dysfunction has also been increasingly discussed in long COVID patients [4,13]. Persistent inflammatory activation following SARS-CoV-2 infection may contribute to microvascular injury, autonomic dysfunction and impaired vascular regulation. Several studies additionally described prolonged exercise intolerance and reduced oxygen utilization months after acute infection [13].

Feng et al. [16] proposed that SARS-CoV-2 may induce prolonged vascular and inflammatory abnormalities through immune dysregulation and endothelial injury, potentially contributing to persistent cardiovascular manifestations observed in long COVID patients.

3.2. Cardiovascular Burden and Metabolic Complications in Chronic Inflammatory Diseases

Chronic inflammatory diseases are frequently associated with metabolic and cardiovascular abnormalities contributing to increased long-term cardiovascular risk [11,21,24].

Several studies reported increased prevalence of obesity, insulin resistance, dyslipidemia and metabolic syndrome among patients with chronic inflammatory disorders. These abnormalities appear particularly pronounced in psoriasis and rheumatoid arthritis, where chronic inflammation may significantly affect lipid metabolism and vascular homeostasis [11,21].

Inflammatory activation was also associated with increased arterial stiffness, impaired vascular elasticity and progression of subclinical atherosclerosis [24,31]. In several studies, vascular abnormalities were identified before development of clinically apparent cardiovascular disease, suggesting that chronic inflammation contributes to early cardiovascular remodeling.

Fatigue, chronic pain and reduced exercise tolerance may additionally promote sedentary behavior, further increasing cardiovascular risk and worsening metabolic profile [7,32]. Some authors suggested that physical inactivity may further amplify inflammatory activation through increased visceral adipose tissue accumulation and impaired metabolic regulation [27]. Prolonged sedentary behavior itself has been identified as an independent cardiovascular risk factor. Reduced daily movement may worsen endothelial dysfunction,

insulin resistance and inflammatory activation even in patients receiving appropriate pharmacological treatment. Some authors therefore emphasize that reduction of inactivity may be clinically beneficial even before introduction of structured exercise programs [32,41].

The connection between inflammation, metabolic dysfunction and reduced physical activity may partially explain why chronic inflammatory diseases are frequently associated with both cardiovascular complications and metabolic abnormalities.

Several studies emphasized that cardiovascular risk assessment in chronic inflammatory diseases should extend beyond traditional cardiovascular risk models and additionally consider inflammatory burden, disease activity and metabolic disturbances associated with chronic immune activation [5,25].

3.3. Effects of Physical Activity on Inflammatory and Cardiovascular Parameters

Most analyzed studies reported beneficial effects of regular physical activity in patients with chronic inflammatory diseases [6,9]. Exercise was associated with improved endothelial function, better metabolic profile, increased exercise tolerance and reduced inflammatory activity.

Gleeson et al. [6] described several mechanisms through which physical activity may exert anti-inflammatory effects. Regular exercise may reduce chronic production of pro-inflammatory cytokines while promoting anti-inflammatory signaling pathways through myokine release and improved metabolic regulation.

Pedersen & Febbraio [17] proposed that skeletal muscle functions as an endocrine organ capable of producing biologically active cytokines during exercise. Exercise-induced IL-6 release was associated with anti-inflammatory and metabolic regulatory effects, which may partially explain the cardiovascular benefits of regular physical activity.

Several studies additionally reported increased nitric oxide bioavailability, improved vascular elasticity and reduced oxidative stress following moderate-intensity exercise interventions. Aerobic exercise was associated with improved cardiovascular fitness and reduced fatigue in patients with systemic lupus erythematosus and rheumatoid arthritis [7,12].

Hanssen et al. [9] emphasized the growing role of individualized exercise prescriptions in cardiovascular prevention and chronic disease management. Similarly, the 2018 EULAR recommendations supported integration of regular physical activity into routine management of inflammatory arthritis [18].

Exercise interventions were also associated with improved quality of life, psychological well-being and physical performance in patients with inflammatory bowel disease and psoriasis. In these populations, regular physical activity was linked to improved body composition and better metabolic regulation.

3.3.1. Exercise and Immunometabolic Regulation

The beneficial effects of physical activity extend beyond cardiovascular fitness alone. Several studies suggested that exercise may influence immunometabolic pathways involved in chronic inflammatory diseases [17,27].

Regular physical activity was associated with improved glucose metabolism, reduced insulin resistance and lower visceral adipose tissue accumulation. These effects may be particularly important in chronic inflammatory diseases, where metabolic abnormalities frequently coexist with persistent immune activation and elevated cardiovascular risk [11,21].

Exercise-induced modulation of inflammatory cytokines also appears to play an important role in cardiovascular protection. Moderate-intensity physical activity may reduce chronic low-grade inflammation through downregulation of TNF- α and other pro-inflammatory mediators while simultaneously promoting anti-inflammatory signaling pathways [6,17].

Physical activity was additionally associated with improved autonomic nervous system regulation and reduced sympathetic overactivation. These mechanisms may partially explain improvements in fatigue, exercise tolerance and cardiovascular parameters observed following appropriately adjusted exercise interventions [27].

3.3.2. Physical Activity and Vascular Remodeling

Regular physical activity may additionally influence vascular remodeling processes associated with chronic inflammatory diseases. Several studies demonstrated that repetitive hemodynamic stimulation during aerobic exercise improves endothelial responsiveness and promotes adaptive vascular changes. Increased shear stress during exercise contributes to enhanced nitric oxide production and improved vascular elasticity, potentially slowing progression of atherosclerotic changes [30,36]. Exercise-related vascular adaptation may be particularly relevant in chronic inflammatory diseases characterized by persistent endothelial injury and arterial stiffness. Green et al. [30] described that regular aerobic exercise promotes favorable vascular remodeling through mechanisms involving endothelial nitric oxide synthase activation, improved antioxidant defense and modulation of inflammatory pathways. Some authors additionally suggested that exercise may improve microvascular function and peripheral tissue perfusion, which could partially explain improvements in fatigue and exercise tolerance observed in physically active patients with chronic inflammatory diseases. Improved vascular responsiveness may also contribute to better oxygen utilization and metabolic efficiency during physical activity [36]. Beneficial vascular effects appear most consistently associated with regular moderate-intensity exercise rather than excessive high-intensity training. Excessive exercise load may transiently increase oxidative stress and inflammatory activation, particularly in individuals with active inflammatory disease or impaired recovery capacity.

3.4. Exercise Limitations and Disease-Specific Challenges

Despite generally positive findings regarding physical activity, several limitations and challenges associated with exercise interventions in chronic inflammatory diseases were identified in the reviewed literature.

Fatigue was one of the most frequently reported barriers limiting exercise participation across multiple disorders. Patients with systemic lupus erythematosus, rheumatoid arthritis and long COVID commonly reported reduced exercise tolerance, impaired recovery and fear of symptom exacerbation.

Particular concerns were observed in long COVID patients, where several studies described post-exertional symptom worsening following higher-intensity physical activity [13]. Persistent fatigue, autonomic dysfunction and impaired cardiopulmonary response may complicate implementation of standardized exercise programs in this population.

Disease activity itself may also significantly influence exercise capacity. During periods of active inflammation, joint pain, muscle weakness and severe fatigue may reduce adherence to physical activity programs. In autoimmune diseases, prolonged corticosteroid therapy may additionally contribute to reduced muscle mass, impaired physical performance and metabolic complications.

The reviewed studies demonstrated substantial heterogeneity regarding exercise protocols, intervention duration and assessment methods. Differences in disease severity, pharmacological treatment and baseline physical capacity limited direct comparison between studies and complicated standardization of exercise recommendations.

Rausch Osthoff et al. [18] emphasized that exercise interventions should be individualized according to disease severity, symptoms and patient tolerance. Although moderate-intensity physical activity was generally associated with beneficial effects, excessive training intensity may worsen fatigue and delay recovery in selected patient groups.

Psychological barriers also influence long-term adherence to exercise interventions. Fear of symptom exacerbation, chronic fatigue and reduced motivation may negatively affect participation in physical activity programs. Several authors suggested that supervised or individualized exercise programs may improve adherence and reduce exercise-related concerns.

Despite these limitations, most studies supported regular physical activity as a beneficial adjunctive strategy in chronic inflammatory diseases when appropriately adjusted to the patient's clinical condition and exercise tolerance.

3.5. Disease-Specific Cardiovascular Manifestations and Exercise-Related Findings

3.5.1. Systemic Lupus Erythematosus

Patients with systemic lupus erythematosus demonstrate one of the highest levels of cardiovascular risk among chronic inflammatory diseases [3,15,19]. Accelerated atherosclerosis, endothelial dysfunction and premature coronary artery disease have been described even in young female patients without classical cardiovascular risk factors.

Esdaile et al. [19] reported that traditional Framingham cardiovascular risk factors do not fully explain the cardiovascular burden observed in SLE patients. Chronic immune activation, vascular inflammation and immune complex-mediated endothelial injury appear to contribute substantially to premature vascular pathology.

Fatigue and reduced exercise tolerance remain major barriers limiting physical activity in SLE patients. Nevertheless, moderate-intensity exercise interventions were generally associated with improved physical performance, reduced fatigue and better cardiovascular fitness [7,12].

3.5.2. Rheumatoid Arthritis

Rheumatoid arthritis is consistently associated with increased cardiovascular morbidity and mortality [2,14,20]. Chronic systemic inflammation contributes to accelerated vascular aging, arterial stiffness and progression of atherosclerosis.

del Rincón et al. [20] demonstrated increased incidence of cardiovascular events among rheumatoid arthritis patients independent of traditional cardiovascular risk factors. Prolonged exposure to inflammatory cytokines such as TNF- α and IL-6 has been repeatedly associated with endothelial dysfunction and vascular injury. Several studies also reported beneficial effects of regular physical activity in rheumatoid arthritis patients. Exercise interventions were associated with improved endothelial function, lower cardiovascular risk and better physical capacity without significant worsening of disease activity [7,18]. Both aerobic and resistance training appear to provide beneficial effects in chronic inflammatory diseases, although their mechanisms may differ slightly. Aerobic exercise is more consistently associated with improvement in endothelial function, vascular elasticity and cardiorespiratory fitness, while resistance training may help counteract muscle loss, physical deconditioning and corticosteroid-related reduction in muscle mass [38]. Some studies additionally suggested that combined exercise programs involving both endurance and resistance components may provide broader cardiometabolic benefits than single-modality interventions alone. Improvement in muscle strength may also contribute to better long-term exercise adherence and improved daily functioning in chronically ill patients [39].

3.5.3. Psoriasis

Current evidence supports the concept that psoriasis represents a systemic inflammatory disease rather than an isolated dermatological condition [11,21]. Increased prevalence of obesity, metabolic syndrome and cardiovascular complications has been reported among psoriasis patients.

Kristensen et al. [21] demonstrated that higher psoriasis disease activity was associated with increased risk of myocardial infarction, stroke and cardiovascular death. IL-17-mediated inflammatory pathways may contribute to systemic cardiometabolic complications observed in this population.

Regular physical activity was associated with improved metabolic profile, body composition and reduced cardiovascular burden in psoriasis patients. Some studies additionally suggested that exercise may contribute to reduction of systemic inflammatory activity.

3.5.4. Inflammatory Bowel Disease

Inflammatory bowel disease is also associated with increased cardiovascular morbidity, although the underlying mechanisms remain less clearly established than in rheumatic diseases [22]. Chronic intestinal inflammation and systemic immune dysregulation may contribute to vascular injury and endothelial dysfunction.

Kirchgesner et al. [22] reported increased incidence of acute arterial cardiovascular events, particularly in younger patients with severe inflammatory bowel disease activity. These findings support the association between inflammatory burden and cardiovascular pathology independent of traditional cardiovascular risk factors.

Several studies suggested that moderate physical activity may improve quality of life, fatigue and metabolic profile in IBD patients. However, gastrointestinal symptoms and disease exacerbations frequently limit exercise participation.

3.5.5. Long COVID

Long COVID represents one of the most recently recognized inflammatory conditions associated with persistent cardiovascular abnormalities [4,13,16,23]. Fatigue, exercise intolerance, autonomic dysfunction and cardiovascular symptoms are among the most frequently reported long-term manifestations.

Davis et al. [23] described prolonged symptom persistence lasting several months after acute SARS-CoV-2 infection, with fatigue and reduced physical capacity representing dominant complaints. Several studies suggested that endothelial dysfunction, autonomic dysregulation and persistent low-grade inflammation contribute to long-term cardiovascular abnormalities observed in long COVID patients.

Persistent tachycardia, impaired aerobic capacity and reduced exercise tolerance were commonly reported. Some studies additionally described abnormalities in heart rate variability and autonomic regulation, suggesting impaired cardiovascular adaptation following SARS-CoV-2 infection [13]. Exercise recommendations in long COVID remain complex. Although light-to-moderate physical activity may benefit selected patients, excessive exercise intensity may worsen symptoms and prolong recovery in individuals experiencing post-exertional symptom exacerbation [13,23]. Current evidence therefore supports individualized exercise strategies with careful monitoring of symptom progression. Recent observations additionally suggest that long COVID may share several pathophysiological features with chronic autonomic and post-viral fatigue syndromes. Persistent dysregulation of autonomic nervous system activity, impaired peripheral oxygen extraction and abnormal cardiovascular adaptation to exertion may contribute to prolonged exercise intolerance observed in some patients [33,37]. Several studies emphasized that pacing strategies and gradual activity progression may be safer than conventional exercise programs in patients experiencing post-exertional symptom exacerbation. Careful monitoring of heart rate response, fatigue severity and recovery time may therefore play an important role in long COVID rehabilitation programs [13,33].

3.6. Digital Health Technologies, Telemedicine and Wearable Devices in Monitoring Cardiovascular and Inflammatory Disease Activity

Growing evidence supports the integration of digital health technologies into the management of chronic inflammatory and cardiovascular conditions. Wearable devices, capable of continuously recording heart rate, heart rhythm and physical activity, have been increasingly applied across cardiology, rheumatology and gastroenterology to support real-time monitoring and personalized care [42]. In cardiovascular rehabilitation, wearable devices combined with telemonitoring were associated with increased physical activity participation and improved cardiorespiratory fitness across several cardiovascular conditions, including coronary artery disease, heart failure and peripheral artery disease [43]. Similar approaches have been explored in rheumatoid arthritis, where activity trackers detected reductions in physical activity and physiological changes preceding symptomatic disease flares, suggesting a potential role in early identification of disease activity [47]. Telemedicine platforms have also been studied as tools for remote disease monitoring in rheumatoid arthritis, allowing patients to report outcomes between in-person visits and improving access to care, particularly where rheumatology follow-up capacity is limited [44]. In inflammatory bowel disease, systematic review evidence indicates that digital health interventions, including web-based monitoring and mobile applications, may reduce healthcare utilization and costs, although their effects on disease relapse and quality of life compared with standard care remain uncertain [45]. Despite this potential, current evidence on the direct impact of digital health technologies on hard cardiovascular outcomes in chronic inflammatory diseases remains limited, and data accuracy, interoperability with electronic health records, and patient engagement remain recognized challenges [42]. Furthermore, unequal access to smartphones, internet connectivity and digital literacy may limit the reach of these tools among socioeconomically disadvantaged or older patients, raising concerns relevant to health equity in the implementation of digital health strategies [46].

4. Discussion

This review demonstrated that chronic inflammatory diseases are consistently associated with increased cardiovascular risk through overlapping inflammatory and vascular mechanisms. Despite differences in clinical presentation and organ involvement, persistent systemic inflammation, endothelial dysfunction and accelerated atherosclerosis emerged as shared mechanisms contributing to cardiovascular complications across the analyzed diseases [2,24].

One of the most important observations identified in the reviewed literature is that traditional cardiovascular risk models do not fully explain the cardiovascular burden observed in chronic inflammatory diseases [19,20]. Several studies described premature cardiovascular pathology even in younger patients without hypertension, smoking history or obesity. These findings support the concept that chronic inflammation itself acts as an independent cardiovascular risk factor [2,25].

Endothelial dysfunction appears to represent a key mechanism linking chronic inflammation with cardiovascular disease progression. Persistent exposure to inflammatory cytokines contributes to impaired nitric oxide bioavailability, oxidative stress and vascular injury, ultimately accelerating atherosclerotic progression [24]. Similar endothelial abnormalities have been described not only in autoimmune diseases such as systemic lupus erythematosus and rheumatoid arthritis, but also in long COVID patients experiencing persistent cardiovascular symptoms [4,16]. The reviewed literature also supports the role of physical activity as a potential modulator of inflammatory and cardiovascular pathways [6,27]. Regular exercise was associated with improved endothelial function, better metabolic profile and increased exercise tolerance across multiple inflammatory diseases [9,28]. Importantly, exercise-related benefits appear to extend beyond improvement in physical fitness alone and may directly influence mechanisms involved in vascular injury and inflammatory regulation. Regular participation in recreational sport and structured physical training may additionally improve body composition, autonomic balance and recovery capacity. In recent years, sports cardiology and exercise medicine have increasingly emphasized the role of regular movement in prevention of chronic low-grade inflammation and cardiovascular dysfunction. Even moderate weekly exercise volume may contribute to measurable improvement in vascular health and metabolic regulation [40]. Importantly, exercise recommendations in chronic inflammatory diseases should not focus exclusively on athletic performance. For many patients, the primary therapeutic goal involves restoration of functional capacity, reduction of fatigue and improvement of long-term cardiovascular health rather than achievement of high exercise intensity.

One particularly relevant mechanism involves the anti-inflammatory effects of myokines released during physical activity [17]. Exercise-induced IL-6 production differs biologically from chronic pro-inflammatory cytokine activation observed in inflammatory diseases and may partially explain the beneficial effects of moderate exercise on inflammatory burden and cardiovascular function.

At the same time, exercise recommendations should remain individualized according to disease activity, fatigue severity and patient tolerance [9,18]. Although moderate-intensity exercise was generally associated with beneficial outcomes, excessive exercise intensity may worsen symptoms in selected patient groups, particularly in long COVID patients reporting post-exertional fatigue and impaired recovery [13].

An important limitation identified during literature analysis was the substantial heterogeneity between available studies. Differences in exercise protocols, duration of interventions, disease activity assessment and cardiovascular outcome measures limited direct comparison between studies. In long COVID, long-term cardiovascular consequences and optimal exercise strategies remain insufficiently understood.

The reviewed evidence also suggests that cardiovascular prevention in chronic inflammatory diseases should not focus exclusively on pharmacological treatment. Integration of individualized physical activity into routine disease management may provide additional cardiovascular and metabolic benefits while simultaneously improving physical performance and quality of life [26]. Overall, current evidence supports a close relationship between chronic inflammation and cardiovascular disease progression. Physical activity appears to represent a valuable supportive strategy capable of influencing both inflammatory and cardiovascular pathways across multiple chronic inflammatory diseases. An important aspect highlighted by the reviewed literature is the growing role of lifestyle-related cardiovascular prevention in chronic inflammatory diseases. Although pharmacological treatment remains essential for controlling inflammatory activity, non-pharmacological interventions may substantially influence long-term cardiovascular outcomes. In recent years, increasing attention has been directed toward combined approaches including exercise, dietary modification, weight control and reduction of sedentary behavior [26,32]. Physical inactivity itself may contribute to worsening inflammatory burden and endothelial dysfunction. Sedentary lifestyle has been associated with impaired glucose metabolism, visceral adipose tissue accumulation and increased production

of pro-inflammatory mediators. Consequently, reduced physical activity may not only worsen cardiovascular fitness but may also contribute directly to progression of inflammatory and metabolic abnormalities [27,32]. Another clinically relevant issue involves the psychological consequences of chronic inflammatory diseases. Chronic fatigue, pain and reduced physical performance may negatively affect mental health, motivation and long-term adherence to exercise programs. Several studies demonstrated that appropriately adjusted physical activity may improve psychological well-being, reduce anxiety and improve overall quality of life in chronically ill patients. The reviewed evidence additionally suggests that early implementation of cardiovascular prevention strategies may be particularly important in younger patients with chronic inflammatory diseases. Cardiovascular complications frequently develop gradually over many years, and subclinical endothelial dysfunction may precede clinically apparent cardiovascular disease. Earlier introduction of individualized exercise interventions could therefore potentially reduce long-term vascular damage and improve overall cardiovascular prognosis [35]. Despite promising findings, further prospective studies remain necessary to better determine optimal exercise intensity, duration and monitoring strategies across different inflammatory diseases. Future studies should additionally evaluate long-term cardiovascular outcomes associated with exercise-based interventions and identify patient groups most likely to benefit from individualized physical activity programs. Further disease-specific prospective studies are still required to establish standardized exercise recommendations and clarify long-term cardiovascular outcomes associated with exercise interventions.

4.1. Future Perspectives and Clinical Implications

Future management of chronic inflammatory diseases will likely require more integrated approaches combining pharmacological treatment with lifestyle-based cardiovascular prevention strategies. Considering the increasing prevalence of both cardiovascular disease and chronic inflammatory disorders, early identification of patients at elevated cardiovascular risk may become increasingly important in routine clinical practice [24].

Several studies emphasized the potential role of personalized exercise interventions adjusted according to disease activity, fatigue severity and cardiovascular burden [9]. Development of individualized exercise programs may be particularly important in diseases characterized by fluctuating symptom intensity, including systemic lupus erythematosus and long COVID.

The growing availability of wearable monitoring devices and digital health technologies may also improve long-term assessment of exercise tolerance, cardiovascular parameters and physical activity levels in patients with chronic inflammatory diseases. Integration of telemedicine and wearable monitoring systems may facilitate safer implementation of individualized exercise interventions in patients with fatigue-related limitations or variable disease activity.

Further prospective studies are required to evaluate long-term cardiovascular outcomes associated with exercise interventions in chronic inflammatory diseases. Although currently available evidence generally supports beneficial effects of regular physical activity, disease-specific exercise recommendations remain insufficiently standardized for several inflammatory conditions.

4.2. Practical Clinical Considerations

From a practical perspective, implementation of physical activity in chronic inflammatory diseases should involve gradual progression and regular assessment of patient tolerance. Exercise recommendations should account for disease activity, fatigue severity, cardiovascular status and comorbidities [18]. Low-to-moderate intensity aerobic exercise remains the most frequently recommended form of physical activity across inflammatory diseases. Walking, cycling, swimming and supervised rehabilitation programs are generally considered safe and may improve both cardiovascular function and exercise tolerance. Clinicians should additionally encourage reduction of sedentary behavior, which itself represents an independent cardiovascular risk factor. Even moderate increases in daily physical activity may provide measurable cardiovascular and metabolic benefits in chronically ill patients [26,32]. Importantly, patient education and individualized counseling may improve adherence to exercise interventions. Long-term success of physical activity programs often depends on realistic exercise goals, symptom monitoring and gradual adaptation of training intensity according to patient tolerance [18].

5. Conclusions

Chronic inflammatory diseases are associated with significantly increased cardiovascular risk, which cannot be explained solely by traditional cardiovascular risk factors [2,19]. Persistent systemic inflammation, endothelial dysfunction and accelerated atherosclerosis appear to represent major mechanisms contributing to cardiovascular complications across diseases such as systemic lupus erythematosus, rheumatoid arthritis, psoriasis, inflammatory bowel disease and long COVID [24].

The reviewed literature suggests that regular physical activity may provide beneficial effects not only on physical performance and quality of life, but also on inflammatory and cardiovascular pathways involved in disease progression [6,28]. Moderate-intensity exercise was most consistently associated with improved endothelial function, reduced inflammatory burden and better cardiovascular fitness.

At the same time, exercise tolerance may differ considerably depending on disease activity, fatigue severity and individual patient characteristics. Particularly in long COVID and active autoimmune disease, excessive exercise intensity may worsen symptoms and impair recovery [13]. Therefore, exercise interventions should remain individualized and adjusted to the patient's current clinical condition.

Overall, physical activity appears to represent an important supportive strategy in the long-term management of chronic inflammatory diseases. Further studies are still required to establish disease-specific exercise recommendations and better understand long-term cardiovascular outcomes associated with exercise interventions in different inflammatory conditions. Digital health technologies, including wearable devices and telemedicine, offer a promising means of delivering individualized, remote exercise monitoring, provided that equitable access to these tools is ensured across diverse patient populations.

Table 1. Cardiovascular manifestations, inflammatory mechanisms and exercise-related findings in chronic inflammatory diseases

Disease	Main cardiovascular manifestations	Key inflammatory mechanisms	Exercise-related findings
Systemic lupus erythematosus	Premature atherosclerosis, endothelial dysfunction, coronary artery disease	Immune complex-mediated vascular injury, cytokine activation	Improved fatigue and cardiovascular fitness after moderate exercise
Rheumatoid arthritis	Increased cardiovascular mortality, arterial stiffness	TNF- α and IL-6 mediated inflammation	Improved endothelial function and exercise tolerance
Psoriasis	Metabolic syndrome, myocardial infarction risk	IL-17-mediated systemic inflammation	Improved metabolic profile and reduced inflammatory burden
Inflammatory bowel disease	Acute arterial events, endothelial dysfunction	Chronic intestinal inflammation and immune dysregulation	Improved quality of life and metabolic profile
Long COVID	Exercise intolerance, autonomic dysfunction	Persistent low-grade inflammation and endothelial injury	Need for individualized low-intensity exercise strategies

Source: own elaboration based on reviewed literature.

Author Contributions: Zuzanna Rak contributed to the conception of the study, literature review, data analysis and preparation of the original manuscript draft. Alicja Wielogórska and Karolina Dzień contributed to methodology development, manuscript revision and supervision of the project. Filip Sarek, Karol Jóźwik, Stanisław Kucharczyk, Zuzanna Ignatowska and Aleksander Kamecki contributed to literature collection, data interpretation and critical revision of the manuscript. All authors approved the final version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study.

Conflicts of Interest: The authors declare no conflict of interest.

Artificial Intelligence Use Disclosure: In preparing this work, the authors used ChatGPT (OpenAI) for minor language correction, grammar improvement and formatting assistance. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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