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Exercise as Medicine: A Review of FITT-Based Physical Activity Prescriptions in WHO and ACSM Guidelines for Health Promotion

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ABSTRACT

Shortfalls in adherence to the Frequency, Intensity, Time and Type (FITT) parameters recommended by the World Health Organization (WHO) and the American College of Sports Medicine (ACSM) continue to limit the preventive potential of physical activity worldwide. This review collates epidemiological, mechanistic and intervention evidence on how precise FITT prescriptions influence cardiometabolic, musculoskeletal and mental-health outcomes, and examines the operational challenges of translating those prescriptions into routine care. We first outline population-level analyses that quantify the independent and combined effects of sedentary time, light movement and moderate-to-vigorous activity on disease risk. Next, we summarise laboratory and field trials that manipulate specific FITT elements, showing graded improvements in glucose regulation, blood pressure, lipid profiles and functional capacity when dose parameters are fully reported and progressively advanced. We then appraise implementation studies that integrate FITT assessment into electronic health records, brief clinician counselling and community delivery, highlighting gains in adherence, equity and cost-effectiveness. Finally, we identify research gaps concerning dose–response relationships, reporting quality, digital support and long-term maintenance, and propose a framework that pairs sitting-time reduction with scalable, culturally tailored FITT prescriptions. Collectively, the evidence supports positioning exercise, quantified through the FITT lens, as a core component of health promotion strategies endorsed by WHO and ACSM.

1. Introduction

Sedentary living and imperfect adherence to the Frequency-Intensity-Time-Type (FITT) parameters in current World Health Organization (WHO) and American College of Sports Medicine (ACSM) guidelines remain widespread despite decades of public-health messaging. Global surveillance indicates that roughly one adult in four fails to achieve the recommended 150–300 min of moderate-to-vigorous physical activity each week and only one in six adds the twice-weekly muscle-strengthening sessions that WHO and ACSM consider essential [1,2]. Such shortfalls contribute to the estimated 7.7–11.5 h of daily sitting now recorded in device-based cohorts, a

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behaviour pattern that carries independent cardiometabolic risk [3]. The persistence of this gap underscores the need to scrutinise how the quantitative FITT framework can be interpreted, delivered, and monitored more effectively across diverse populations.

Large epidemiological datasets that couple accelerometry with health outcomes have clarified how sedentary time and FITT-defined activity volumes interact. Reallocating just 30 min of sitting to light-intensity movement predicts 2–4% improvements in pooled cardiovascular risk factors, while substituting the same duration with moderate-to-vigorous activity yields even larger gains [4]. These observations align with isotemporal modelling showing prolonged, uninterrupted bouts of sitting amplify disease risk, particularly among adults with low overall activity [3]. Advances in wearable technology have therefore shifted the research lens from self-reported totals toward high-resolution mapping of frequency, intensity, and bout distribution metrics that better capture real-world compliance with FITT prescriptions [5].

Randomised trials now demonstrate that tailoring exercise prescriptions to specific FITT doses elicits clinically meaningful benefits across cardiometabolic, musculoskeletal, and mental-health outcomes. For example, meeting both aerobic and resistance targets lowers HbA1c by up to 0.7% in adults with type 2 diabetes, surpassing usual care controls, while combined aerobic-resistance formats outperform single-mode programmes for depressive-symptom reduction [6]. Yet many trials still omit critical FITT details in their protocols and reports, limiting meta-analytic synthesis; application of the Consensus on Exercise Reporting Template revealed frequent under-reporting of session frequency and load progression [7].

Embedding FITT-based prescriptions into routine care poses additional challenges. Pragmatic Exercise is Medicine initiatives have increased written prescriptions in primary care but sustaining adherence beyond six months remains uncommon [8]. Emerging digital platforms offer real-time feedback and adaptive dosing, yet early comparisons show variable accuracy and inconsistent safety screening when plans are generated by artificial intelligence rather than clinicians [9]. Equity further complicates implementation; culturally adapted, low-cost programmes in low- and middle-income settings are scarce, and long-term maintenance data rarely extend past twelve months [10].

Against this backdrop, the present review examines how WHO and ACSM recommendations operationalise the FITT paradigm, evaluates dose-response evidence across life stages and clinical populations, and critiques implementation strategies that aim to turn “exercise as medicine” into routine practice. By synthesising observational, experimental, and translational findings, we aim to clarify where current guidance succeeds, where evidence gaps persist, and how future research can refine FITT-based prescriptions to maximise population health impact.

2. Review

2.1 FITT-Structured Activity and Cardiometabolic Health

Understanding the preventive value of precise FITT prescriptions has consolidated rapidly since major authorities harmonised aerobic and muscle-strengthening targets for adults and older adults in the 2020 WHO and ACSM’s guidelines for prescribing exercise [2,3]. Both documents affirm that accruing 150–300 min. week^{-1} of moderate-intensity or 75–150 min. week^{-1} of vigorous-intensity activity, combined with strength training on at least two days, yields substantive cardiometabolic benefit, and they discard the earlier 10-min bout rule to emphasise that every movement counts. This consensus has reframed clinical and public-health messaging, encouraging policy makers to pair the established aerobic dose with strategies for sitting-time reduction and multicomponent programming that enhance functional capacity across the life course.

Large-scale surveillance data reveal, however, that adherence to these FITT benchmarks remains suboptimal. In a nationally representative US sample, only 45% of adults met aerobic targets, and just 24% fulfilled both aerobic and strength guidelines when compliance was assessed by self-report, with little improvement between 2008 and 2018 [1,11]. Device-based estimates suggest an even greater gap: accelerometer studies indicate that adults typically accumulate barely 20 min.day^{-1} of moderate-to-vigorous physical activity (MVPA) while remaining sedentary for 8–11 h [12]. These findings underscore the need to examine not only total MVPA but also the qualitative composition of weekly FITT prescriptions delivered in community and clinical settings.

Dose–response evidence from prospective cohorts reinforces the public-health urgency. A harmonised meta-analysis of nine accelerometer-based studies showed that, relative to the lowest quartile of MVPA (<75 min. week^{-1}), the risk of all-cause mortality declined by 28%, 34%, and 48% across successive quartiles, with benefits apparent well below current targets [13]. Conversely, every additional hour of daily sedentary time elevated mortality risk by 11%, even after adjustment for MVPA, prompting WHO to encourage replacement of sitting with activity of any intensity [14]. These population-level data clarify the intertwined contributions of total volume and movement pattern to long-term health.

Cardiovascular outcomes exhibit a similar gradient. Analyses of more than 750,000 person-years indicate that each 10 MET/h increase in weekly MVPA (i.e., equivalent to an extra 180 min of brisk walking) corresponds to a 9% reduction in incident coronary heart disease [15]. Importantly, strength training twice weekly confers an additional 17% risk reduction independent of aerobic volume, yet only one in five adults' reports meeting this component, highlighting an implementation deficit in routine prescriptions [1]. These divergent adherence patterns affirm the necessity of scrutinising how clinicians document and dose FITT variables, particularly resistance training, within standard care pathways.

Cardiorespiratory fitness modifies many of these associations. In youth cohorts, each one-standard-deviation increase in fitness attenuates clustering of cardiometabolic risk factors by up to 30% [16] and meta-analytic data show that adults with high baseline fitness exhibit weaker links between prolonged sitting and insulin resistance than their low-fitness peers [17]. Nevertheless, achieving the fitness thresholds required to neutralise sedentary risk often demands volumes exceeding guideline minimums, thereby reinforcing the call for comprehensive prescriptions that balance intensity, frequency, and recovery to drive adaptive gains safely.

Further insights from isotemporal-substitution analyses indicate that replacing 30-minute segments of sedentary time with light activity lowers combined cardiovascular and all-cause mortality by 11%, whereas reallocating the same duration to MVPA reduces these outcomes by 36% among community-dwelling adults aged 70 years and older [18]. Concordant findings from pooled cohort data project that exchanging 1 hour.day^{-1} of sitting for movement of any intensity could avert 3–4% of premature deaths worldwide [4]. Together, these modelling studies reinforce the premise that dispersing sedentary time through frequent, FITT-aligned bouts of activity provides a pragmatic route to attenuate cardiometabolic risk across populations.

2.2 Mechanistic Pathways of FITT-Aligned Physical Activity

Adults in high-income nations now spend more than seven waking hours per day seated, a behaviour that associates with higher incidence of type 2 diabetes, cardiovascular disease, and all-cause mortality [19]. Prospective device-based cohorts indicate that reallocating 60–75 min of moderate-intensity activity to replace sedentary activities normalises mortality risk, whereas smaller volumes leave a significant hazard [20]. These dose–interaction data justify examining how the modifiable FITT dimensions of movement interact to counter the biological sequelae of sedentary behaviors. Understanding these mechanisms will allow clinicians to prescribe targeted activity that is both feasible and protective within modern sedentary lifestyles.

2.2.1 Vascular function

Sustained elevations in vascular shear stress underpin many cardiovascular adaptations to exercise. Twelve to sixteen weeks of high-intensity interval training (HIIT) raise brachial-artery flow-mediated dilation (FMD) by roughly 4%, exceeding the ~2% gain achieved after comparable volumes of moderate continuous training, an effect attributed to the larger shear stimulus imposed by higher intensities [21]. Conversely, brief walking bouts accumulated as three ten-minute sessions per day over six months lower carotid–femoral pulse-wave velocity by 0.4 m. s^{-1} in overweight adults, demonstrating that greater frequency can compensate for shorter bout duration [22]. These findings suggest that either intensity or repetition can deliver hemodynamic stress sufficient to remodel the endothelium, provided that total weekly time approaches guideline recommendations.

Acute mechanistic work corroborates the central role of shear. Each contraction-induced surge in blood flow augments antegrade shear, promoting nitric oxide release and suppressing endothelin-1 [23]. When investigators externally occlude shear during cycling, endothelial benefits disappear, confirming a causal relationship [24]. Importantly, accumulated micro-bouts supply multiple shear “pulses” across the day. This pattern explains why three daily ten-minute walks match a single continuous thirty-minute session for FMD enhancement, while simultaneously avoiding the femoral-artery angulation that typifies uninterrupted passive leisure activities [25]. Therefore, prescribing distributed activity breaks can achieve vascular conditioning without lengthy exercise blocks.

2.2.2 Blood pressure regulation

Blood-pressure regulation displays a similarly flexible response to FITT manipulation. A single moderate-intensity session lowers clinic systolic pressure by 4–5 mmHg for up to ten hours, an effect termed post-exercise hypotension [26]. Repeating this stimulus on at least three days weekly reduces 24-hour ambulatory systolic pressure by approximately 3 mmHg in hypertensive adults [27]. Interval prescriptions produce comparable acute hypotensive effects; some data show marginally greater daytime reductions after HIIT, suggesting an intensity dose–response [28]. Importantly, when moderate sessions are substituted for prolonged sitting with no additional activity, the hypotensive benefit is attenuated, highlighting the antagonistic influence of sedentary exposure.

Autonomic modulation partly explains these blood-pressure changes. In adults with type 2 diabetes, eight hours of consolidated inactivity elevate plasma noradrenaline by 15%, whereas inserting three-minute brisk walks every half hour blunts this catecholamine rise and lowers mean arterial pressure by 5 mmHg [29]. Trials that titrate break intensity report greater sympathetic withdrawal and baroreflex sensitivity at vigorous versus moderate pace, underlining the capacity of intensity to scale autonomic benefit [28]. Thus, frequent, short, and purposeful breaks can restore autonomic balance disrupted by sedentary behaviour.

The biomechanics of posture further contribute to risk. Hip and knee flexion during sitting bends the femoral and popliteal arteries, creating disturbed flow and low oscillatory shear that promote endothelial dysfunction [30]. Standing workstations or light stepping remove arterial angulation and preserve leg FMD after three hours compared with a 45% decline during uninterrupted sitting [31]. Prescribing five-minute standing or stepping breaks every 30 minutes therefore eliminates a mechanical impediment while accumulating light-activity minutes toward weekly MVPA targets.

2.2.3 Glucose and lipid metabolism

Glycaemic control demonstrates strong dependence on total weekly volume but also gains from strategic timing. Meta-analysis indicates that 150 min of moderate activity per week lowers HbA1c by 0.6 percentage points regardless of bout pattern [32]. In randomised crossover trials, afternoon exercise attenuates 24-hour glucose more effectively than identical morning sessions in adults with type 2 diabetes, possibly through circadian alignment of muscle glucose transporter-4 translocation [33]. Hence, clinicians may leverage timing within the FITT framework to maximise glycaemic benefit without increasing total exercise time.

Lipid metabolism adapts more gradually yet still responds to FITT dosing. Two-day interventions that break low-movement routines with light walking lower post-prandial triacylglycerol by about 12%, but more pronounced chronic effects arise when weekly aerobic and resistance volumes exceed ten metabolic-equivalent hours, boosting HDL functionality and depressurising pro-inflammatory lipid species [33]. Lipidomic profiling after sprint-interval protocols reveals acute elevations in fatty-acid oxidation intermediates and plasmalogens that may signal long-term lipid remodelling [34]. Incorporating resistance sessions into predominantly aerobic programmes therefore diversifies the metabolic stimulus.

2.2.4 Neurocognitive and mental-health pathways

Cognitive function during sedentary tasks also benefits from activity breaks. Middle-aged office workers who walked three minutes at light to moderate pace each half hour maintained working-memory accuracy and positive affect across a three-hour laboratory period, whereas prolonged sitting periods impaired both outcomes [35]. These micro-breaks totalled only 18 min of movement yet supplied repeated haemodynamic and neurochemical stimuli. Implementing such strategies can raise MVPA adherence without extending formal exercise sessions.

Cerebrovascular adaptations accompany these systemic gains. A single twenty-minute vigorous cycling bout elevates serum brain-derived neurotrophic factor (BDNF) by roughly 30%, enhancing synaptic plasticity [36]. Year-long moderate-vigorous walking three times weekly enlarges hippocampal volume by 2% in older adults and improves memory performance [37]. Device-based field studies confirm that every additional 2,000 daily steps are associated with a 2% higher cerebral blood-flow velocity, independent of cardiorespiratory fitness [35]. Together, these data illustrate that FITT thresholds sufficient for cardiovascular benefit simultaneously support brain health.

2.2.5 Inflammation and metabolomic

Low-grade systemic inflammation integrates many risk pathways. Regular moderate or vigorous activity in accordance with international guidelines lowers C-reactive protein and interleukin-6 by 10–15%, effects amplified when daily stationary tasks are simultaneously reduced [19]. High-intensity activity that interrupts sedentary behaviours also curtails acute salivary IL-8 responses compared with continuous low-energy activities, showing how intensity and pattern interact to temper inflammatory signalling [38]. These findings underscore the necessity of combining movement prescription with sedentary-time reduction for maximal anti-inflammatory effect.

Metabolomic investigations illustrate the systemic reach of activity dosing. Ten minutes of micro-interval cycling induces large, transient spikes in glycolytic intermediates, branched-chain amino acids, and oxidative-stress markers followed by super-compensatory declines during recovery [34]. Repeated exposure to this metabolic flux improves mitochondrial density and lipid oxidation, supporting guideline language that "every minute counts" provided intensity suffices. Such insights aid the tailoring of short, potent exercise to individuals unable to allocate long continuous sessions. Table 1 outlines the potential physiological impact of prolonged sitting versus regular physical activity.

Table 1
Potential physiological impact of prolonged sitting versus regular physical activity

System	Predominantly inactive / sitting	Regularly active
Vascular function [21-23]	• Low shear stress at the vessel wall • Endothelin-1 rises, nitric oxide falls → net vasoconstriction • Flow-mediated dilation impaired	• Repeated shear stress pulses during muscle contraction • Nitric oxide bioavailability higher, endothelin-1 lower → net vasodilation • Greater flow-mediated dilation and arterial compliance
Blood pressure [26,27]	• Sympathetic tone chronically elevated • Resting systolic and diastolic pressure higher • Baroreflex sensitivity blunted	• Lower resting pressure (≈4–5 mmHg systolic, 2–3 mmHg diastolic on average) • Improved baroreflex function and heart-rate variability
Glucose and insulin [32,33]	• Skeletal-muscle GLUT4 translocation sluggish • Post-prandial glucose peaks higher and last longer • Hyperinsulinaemia and insulin resistance emerge	• GLUT4 translocation rapid during and after activity • Smaller post-prandial glucose excursions • Higher insulin sensitivity and lower fasting insulin
Lipid metabolism [34]	• Lipoprotein lipase activity in muscle capillaries suppressed • Triglycerides accumulate; HDL-C falls	• Lipoprotein lipase activated during each muscle-pump cycle • Lower fasting and post-prandial triglycerides; HDL-C rises
Inflammatory profile [38]	• C-reactive protein, IL-6, TNF-α elevated • Endothelial adhesion molecules upregulated	• Lower circulating inflammatory cytokines • Improved endothelial glycocalyx integrity
Cerebral blood flow & cognition [35]	• Cerebral perfusion declines during prolonged sitting bouts • Executive function and mood acutely dip	• Activity breaks restore cerebral perfusion within minutes • Better acute attention and long-term cognitive resilience

2.2.6 FITT-Induced non-response

The notion of "exercise resistance" emphasises dose personalisation. Pooled analyses of fourteen endurance-training studies found that participants who failed to raise VO_2max with 150 min week^{-1} invariably responded when weekly volume doubled, reducing true non-response to below 5% [39]. Clinicians should adjust FITT variables upward before classifying a patient as a non-responder, while maintaining confidence in public-health minimums as an effective baseline for most.

2.2.7 Future directions

Future work must translate these mechanistic insights into scalable practice. Wearable-guided auto-regulation has raised MVPA adherence to 90% in pilot cardiac-rehabilitation studies and improved VO_{2max} by 10% over eight weeks [40]. Artificial-intelligence platforms now generate real-time FITT prescriptions personalised to fatigue and glucose metrics, yet require rigorous validation for safety and equity in resource-limited clinics [41]. Addressing these gaps will clarify how structured exercise and inactivity-time reduction can be integrated within clinical pathways.

3. Implications for Practice and Scalability

Embedding full FITT parameters into everyday care is practical when these elements are treated as a clinical vital sign rather than an optional add-on. Adding a *Physical Activity Vital Sign,* which is a templated prescription pad and a short referral script increased the share of patients who left primary-care visits with a written exercise plan from 12% to 73% and produced an average 38-minute weekly rise in MVPA at six months [8]. Comparable mixed-method audits in Dutch and Swedish hospital networks show that when clinicians could delegate counselling to allied health staff and auto-populate FITT fields in the electronic record, prescription rates rose nearly eight-fold and remained stable at follow-up [42,43]. Despite this progress, population surveys still find only about one-third of adults recall any exercise advice in the previous year, underscoring that standardised electronic prompts, concise hand-off scripts, and protected time for brief advice are the levers that convert clinician intent into action. Systematic reviews confirm that such workflow adaptations outperform isolated financial incentives and close a persistent adoption gap between endorsement of exercise and delivery of a detailed FITT plan [44].

Behaviour changes in multimorbid or deconditioned adults tends to follow an incremental trajectory. Trials that first asked participants to break sitting time by 30–60 minutes per day before adding light activity achieved 83% adherence and no adverse events, whereas comparable programmes that started with brisk walking saw adherence fall below 50% by week eight [45]. Digital platforms can automate these staged progressions, yet evaluations of current chatbots reveal that 59% of high-risk profiles lack at least one essential safety screen [46]. Hybrid models in which an algorithm drafts the progression, and a clinician edits the plan achieve guideline concordance similar to expert-only prescriptions while halving staff time per patient [47]. Short-term trials of app-based coaching report increases in cardiorespiratory fitness comparable to supervised sessions, although gains in total activity minutes often wane without human follow-up [48,49]. Until liability and regulatory frameworks mature, a prudent route is a human-in-the-loop design in which algorithms handle triage and draft FITT parameters, but qualified professionals verify intensity thresholds, contraindications and contextual barriers before release [50]

Economic modelling consistently ranks brief FITT-aligned counselling among the most efficient preventive services. Meta-analytic data show that clinician advice increases the odds of meeting WHO activity targets by about 40% at one year [44]. When short-term mental-health gains are included, the incremental cost-effectiveness ratio is roughly US $2,300 per quality-adjusted life-year, substantially below common willingness-to-pay thresholds [51]. Pedometer programmes mailed from primary care avert disability-adjusted life-years at about US $20 each [52], and systematic reviews confirm that most community or clinic-based interventions are either cost-neutral or cost-saving, especially when they rely on brief advice rather than supervised sessions [53]. These findings remove the financial rationale for inaction: integrating FITT assessment into routine care yields population-level health gains at a marginal cost comparable to smoking-cessation counselling and hypertension screening.

Extending delivery beyond specialist and urban clinics requires models that leverage community assets. Cluster trials in Vietnamese-American families and church-based programmes for Latinas doubled the proportion achieving 150 minutes of weekly activity when lay health workers delivered culturally tailored FITT scripts [54,55]. These workers not only translate guidelines but also organise group walks, park sessions and peer networks, enhancing social support while keeping programme costs low. Equipment-free routines that includes stair climbing, calisthenics and brisk neighbourhood walking, could produce cardiorespiratory and strength gains on par with gym-based training when intensity and volume are matched [56,57]. Because these activities rely on public spaces and body weight, they remove financial and logistical barriers that often hinder sustained engagement in low-resource settings. The progressive route for embedding complete FITT prescriptions into everyday care is shown in Figure. 1 (Scalable FITT Step), which traces how practice can advance from ad hoc remarks to lay-led community programmes while steadily improving prescription rates, patient adherence, cost-effectiveness and overall population reach. Specifically, most consultations start on a narrow baseline of ad hoc advice; moving up the first step, streamlined workflows that record a Physical Activity Vital Sign and auto-populate FITT fields lift written prescription rates from roughly 12 % to more than 70 % and add about 38 weekly minutes of moderate-to-vigorous activity. The second step introduces a sit-less target before light movement, securing adherence above 80 % and preventing the early dropout seen when programmes launch with brisk walking. The third step shows that brief, guideline-aligned counselling delivers an incremental cost-effectiveness. At the top step (fourth step), lay health workers using culturally tailored FITT scripts in churches, family networks, or neighbourhood groups double the share of adults who achieve 150 minutes of weekly activity with equipment-free routines that keep costs low. The diagonal arrow labelled "Scale and Impact" indicates the expected rise in population reach and health benefit as services climb the staircase.

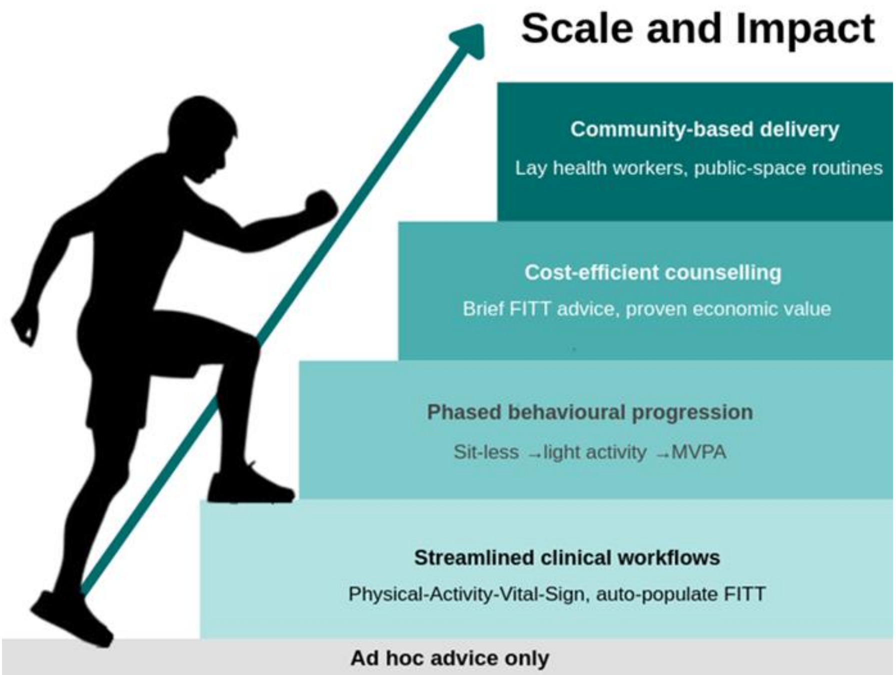

Fig. 1. Scalable FITT Step. Four-step staircase for adding FITT to care: record a physical activity vital sign, promote sit-less progression, offer brief FITT counselling, and run peer-led community sessions, with each step raising reach, adherence, and cost-efficiency

Indeed, the evidence positions streamlined clinical workflows, phased behavioural progression, cost-efficient counselling and community-embedded delivery as mutually reinforcing pillars of scalable practice. Synthesising dose–response relationships, adherence strategies and equity considerations will allow future guideline makers to refine quantitative targets and help policymakers to allocate resources where they yield the largest health dividends.

4. Conclusions

Insufficient adherence to the activity volumes continues to undermine global efforts to curb preventable disease. The literature reviewed here indicates that prescriptions anchored in the FITT framework and explicitly linked to the current WHO and ACSM targets, can narrow the persistent gap between population guidelines and everyday behaviour. Large device-based cohorts reveal that trading as little as 30 minutes of sedentary time for light movement yields small yet clinically meaningful gains in blood pressure, glucose regulation and affect, whereas substituting the same interval with moderate-to-vigorous activity magnifies those benefits. Randomised interventions further demonstrate that when clinicians document complete FITT parameters and stage behaviour change—from sitting interruption to light stepping, to guideline-level aerobic and resistance workloads—adherence surpasses that of generic advice, and improvements in lipids, insulin sensitivity and functional capacity accumulate within six months. Despite such encouraging signals, current evidence is limited by short follow-up, incomplete reporting of progression variables and scarce data from low-resource settings. Harmonised dose–response meta-analyses that integrate accelerometer, self-report and biomarker outcomes are needed to clarify minimal effective doses, upper safety thresholds and the relative influence of resistance versus aerobic formats across ages and comorbidity profiles. Future trials should also evaluate scalable, digitally supported programmes that pair continuous monitoring with adaptive FITT dosing, while reporting all prescription elements with transparency and tracking long-term maintenance, safety and equity metrics. In parallel, health systems can act now by embedding a physical-activity vital sign in electronic records, training clinicians to issue brief, quantified prescriptions and partnering with community services capable of delivering culturally tailored, equipment-free routines. Collectively, these steps would align clinical practice with the mechanistic and epidemiological evidence reviewed, lessen the burden of sedentary lifestyles and advance the goal of making exercise a routinely prescribed component of preventive and therapeutic care.

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