



## Myths and reconstruction of workplace exercise prescriptions: A critical review from the perspective of Critical Exercise Medicine

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### Abstract

Sedentary behaviour has been framed as the leading modifiable health-risk factor among modern office-based workers, giving rise to four core intervention paradigms: flexibility training, balance training, micro-exercise for sedentary-behaviour interruption, and exercise-mediated stress modulation. Most existing studies validate the physiological benefits of these interventions within a biomedical framework yet lack systematic reflection on mechanistic uncertainties, methodological flaws, limitations in ecological validity, and structural contradictions in real-world implementation. Adopting the lens of critical exercise medicine, this paper synthesizes 37 SCI journal empirical studies to conduct a multi-layered examination of the four intervention modules. Findings show that the cardiovascular protective effects of static stretching are plagued by methodological heterogeneity and confounding factors such as the Valsalva manoeuvre, its acute force-inhibitory effect and risk of over-stretching injury have long been selectively overlooked. Evidence supporting balance training draws heavily on fall-prevention research in older adults, and direct extrapolation to young-to-middle-aged working adults raises concerns regarding insufficient dosage and ambiguous effect boundaries. Metabolic benefits of sedentary-behaviour interruption are largely confined to short-term post-prandial experimental contexts, while cognitive switching costs and workflow disruption are systematically underestimated, sit-stand desks present a practical paradox marked by progressive adherence decay. The hypothalamic-pituitary-adrenal (HPA)-axis-regulating effects of exercise-based stress reduction exhibit pronounced heterogeneity across sex and stress typologies, and the endocannabinoid hypothesis remains restricted to acute-effect observations. Individualising workplace stress as a problem of “insufficient exercise” further entails ethical risks of responsibility displacement. Accordingly, this paper critiques biomedical reductionism and individual-responsibility bias embedded in current workplace exercise prescriptions. Drawing on the social-ecological model, we propose re-evaluating the evidence grade of interventions, weighing health gains against productivity costs, strengthening organisation-level supportive structures, and conducting long-term follow-up research grounded in local real-world workplace settings. These steps may facilitate the construction of an ecologically valid and socially just paradigm for workplace health promotion.

**Keywords:** Sedentary behaviour, critical exercise medicine, flexibility training, balance training, sedentary-behaviour interruption, HPA axis, methodological reflection, social-ecological model

### Introduction

#### Pathologisation of Sedentary Behaviour and the Rise of Individual-Responsibility Discourse

Over the past two decades, sedentary behaviour has evolved from a purely postural descriptor to an epidemiologically-constructed chronic-disease risk factor independent of insufficient physical activity. Data documenting 8-10 hours of daily sitting among global adults, together with evidence linking prolonged sitting to type-2 diabetes, cardiovascular disease and all-cause mortality, underpin the discourse of a “sedentary crisis”. The core logic holds that sedentary behaviour constitutes an individually modifiable behaviour, and thus responses to its health risks should primarily target individual behavioural change. From a critical public-health perspective, however, the prevalence of sedentary behaviour is fundamentally a product of industrial restructuring and transformations in labour organisation. Temporal rhythms, spatial layouts and task attributes of contemporary office labour structurally prioritise sitting; overtime culture, performance pressure and meeting schedules further compress opportunities for physical activity during work hours. Reducing the health toll of sedentary work to “insufficient individual willpower for exercise” ignores structural workplace constraints and may generate moral pressure centred on individualised health responsibility: employees’ health issues are attributed to

poor self-discipline rather than defective organisational environments. Most exercise-medicine literature follows a linear logic: *document harms* → *propose interventions* → *verify effectiveness*. Few studies reflect on intervention boundaries, risks and associated costs. In reality, every exercise intervention entails both benefits and costs; improvements in physiological markers do not automatically translate to holistic health or enhanced quality of working life. For sedentary workers, exercise interventions are not merely biomedical concerns but also issues of organisational management, workplace productivity and social equity.

#### Four Major Workplace Exercise-Intervention Modules and Their Research Paradigms

Consensus holds that after-work exercise alone cannot fully offset daytime sedentary harms, prompting exercise-medicine researchers to develop four workplace-specific intervention strategies: flexibility training, balance-sensorimotor training, daytime sedentary-behaviour-interrupting micro-exercise, and exercise-mediated neuroendocrine stress regulation. Targeting vascular injury, proprioceptive deterioration, metabolic disturbance and neuroendocrine dysregulation respectively, these four modules form an integrated “vascular-neural-metabolic” intervention framework. This

framework advances beyond traditional binary prescriptions of aerobic plus resistance training by acknowledging low-intensity, fragmented, context-specific physical activity. Nevertheless, existing research exhibits three systematic biases. First, validation orientation: most studies aim to confirm positive intervention outcomes while neglecting adverse effects, marginal effects and applicability boundaries. Second, biological reductionism: excessive focus on physiological markers sidelines broader dimensions including cognition, affect and productivity. Third, de-contextualisation: research is predominantly conducted under tightly-controlled laboratory conditions, with insufficient consideration of real-world workplace variables such as organisational culture, work tasks and social norms, which compromises the ecological validity of empirical conclusions.

### **The Perspective of Critical Exercise Medicine and Paper Structure**

Critical exercise medicine does not outright reject exercise interventions. Instead, it advocates rigorous, context-aware appraisal of evidence and reflective practice. Core concerns include methodological quality and generalisability of evidence, potential risks and unintended consequences of interventions, attribution of health responsibility and social equity, and paradigm bias shaping knowledge production. This paper conducts a critical analysis of each of the four intervention modules. Chapter 2 examines controversies surrounding cardiovascular effects of flexibility training alongside costs of acute force inhibition and injury risks from over-stretching. Chapter 3 analyses evidence gaps and ecological-validity challenges when extrapolating balance-training evidence from older adults to young-to-middle-aged working populations. Chapter 4 discusses boundaries of metabolic benefits for sedentary-behaviour interruption, cognitive costs and practical paradoxes of environmental modifications. Chapter 5 reflects on mechanistic heterogeneity in exercise-driven stress reduction, limitations of the endocannabinoid hypothesis and ethics of responsibility displacement. Chapter 6 critiques paradigm bias in integrated prescriptions and outlines reconstruction directions informed by a social-ecological perspective. Finally, core findings are summarised and prospects for critical turns in future research are presented. This paper systematically reviews 37 SCI publications spanning exercise medicine, physiology and public-health disciplines, incorporating randomised controlled trials (RCTs), systematic reviews and meta-analyses, longitudinal studies and qualitative research to ground its critique in diverse, robust empirical evidence.

### **Dual Faces of Flexibility Training**

#### **1. Cardiovascular Protective Effects**

Within traditional exercise science, flexibility training is understood to improve joint range-of-motion, alleviate muscle soreness and prevent sports-related injury. Over the past decade, findings that static stretching improves endothelial function, reduces arterial stiffness and lowers blood pressure have greatly expanded its perceived utility, establishing it as a low-threshold vascular-protection strategy for sedentary office workers. The proposed mechanism holds that mechanical stretch stimulates vascular endothelial cells, up-regulating nitric-oxide (NO)

bioavailability and thereby relaxing vascular smooth muscle and enhancing arterial compliance. Close inspection of available evidence reveals substantial methodological heterogeneity in the magnitude and stability of such effects. First, many studies feature small sample sizes and high heterogeneity. A systematic review and exploratory meta-analysis by Themistocleous *et al.* (2026) <sup>[31]</sup> among hypertensive populations detected significant systolic and diastolic blood-pressure reductions following stretching training. Sensitivity analyses, however, demonstrated large effect-size fluctuations alongside variable methodological quality; several studies lacked blinding and random-sequence concealment. Much evidence derives from passive-stretching experiments where therapists or equipment apply tensile force, which differs fundamentally from self-administered active stretching among office workers in terms of muscle-activation patterns and shear-stress magnitude. Muscles fully relax during passive stretching, enabling more complete vascular-bed distension; during active stretching, compensatory contraction of antagonistic muscles frequently occurs and may attenuate haemodynamic stimulation. Crucially, confounding effects of the Valsalva manoeuvre are rarely discussed. Untrained individuals often hold their breath during maximal stretching, raising intrathoracic pressure, impeding venous return and triggering acute blood-pressure elevation. Research documents significant systolic-blood-pressure spikes during multi-set hip-flexor stretching protocols, with cumulative effects increasing across sets. Long-term consequences of such acute blood-pressure fluctuations among pre-hypertensive individuals remain unevaluated. In short, the conclusion that “stretching lowers blood pressure” relies upon standardised, well-executed movement. Poor-form stretching performed by untrained office workers in real-world settings may yield distinctly different haemodynamic outcomes.

#### **2. Acute Force-Inhibitory Effects**

While workplace-health literature promotes stretching benefits, it largely ignores a well-established exercise-science observation: prolonged static stretching acutely reduces maximal muscular strength and power output. A systematic review and multi-level meta-analysis across the lifespan by Arntz *et al.* (2023) <sup>[1]</sup> confirmed that although chronic static stretching exerts weaker negative effects on strength and power than acute stretching, dose-dependent impairments persist. Protocols incorporating stretches exceeding 60 seconds per repetition with multiple sets produce measurable decrements in force performance. For working populations, this carries practical implications. Prolonged static stretching immediately prior to manual labour, precision-equipment operation or tasks requiring fine muscular control may increase error and injury risk. Even for white-collar workers, reduced core-muscle tone can compromise sitting stability and exacerbate postural compensation during subsequent sedentary periods. Traditional training principles recommend dynamic stretching pre-exercise and static stretching post-exercise, yet this nuance is simplified to “stretching is beneficial” in workplace contexts. Inter-task stretching at work can relieve muscular tension, yet blind promotion without considering timing, duration and subsequent task demands may prove counter-productive. Workplace-intervention studies almost never measure how stretching influences work-related physical performance, representing a notable evidence gap.

### 3. Soft-Tissue-Injury Risk from Over-Stretching

The subjective guideline “mild discomfort without sharp pain” is commonly used to define safe static stretching. This threshold varies markedly across individuals, however; altered pain thresholds among long-term sedentary persons with degraded proprioception may lead to unintentional over-traction. Sports-injury research identifies the myotendinous junction as the musculoskeletal system’s weakest site. Repeated over-stretching may trigger micro-tears in collagen fibres and cumulative overuse injuries, in severe cases producing partial muscle rupture. Dobias & Říha (2025) <sup>[6]</sup> reported a case of medial gastrocnemius rupture secondary to progressive stretching among a patient with spastic paresis, illustrating that purportedly gentle static stretching carries injury potential in persons with diminished tissue elasticity. Among sedentary office workers, hip flexors and hamstrings remain chronically shortened; connective-tissue fibrosis reduces elastic reserve. Hasty pursuit of “increased flexibility” via ballistic movement or stretching beyond physiological limits can precipitate soft-tissue injuries affecting the lumbar spine and lower extremities. Moreover, augmented joint range-of-motion through excessive stretching may reduce joint stability. Over-traction of ligaments and joint capsules diminishes passive stabilising structures; among sedentary individuals with inadequate core strength, this may heighten risks of joint malalignment and compensatory injury. Greater flexibility does not equate to better health; optimal function requires balance between range-of-motion and joint stability, a consideration largely erased within discourse framing “flexibility = health”. In summary, regular static stretching holds potential cardiovascular benefits, yet supporting evidence is of moderate certainty, constrained by limited sample representativeness, divergent movement patterns and inadequate confounding-variable control. Clinical significance should not be over-interpreted. Acute force-reduction effects and soft-tissue-injury risk represent non-negligible marginal costs.

For sedentary workers, flexibility training is best conceptualised as a low-intensity, short-duration, targeted workplace-relaxation tool rather than an independent therapeutic cardiovascular intervention. Implementation principles should emphasise movement standardisation (avoiding breath-holding and excessive exertion), duration limits (20-30 seconds per tissue site, avoiding durations above 60 seconds), careful timing (avoiding performance immediately prior to tasks requiring fine muscular output), and individualised adaptation aligned with baseline flexibility rather than universal movement benchmarks. Portraying flexibility training as a zero-cost, universally-beneficial panacea contradicts scientific evidence and impedes realistic risk awareness among end-users.

### Evidence Gaps Surrounding Balance Training

#### 1. Paradigm Shift Underpinning Evidence Bases

Balance training has entered workplace exercise prescriptions based on the logical chain: *sedentary behaviour degrades proprioception, impairing postural control*. Although this reasoning has merit, robust evidence for balance-training efficacy derives almost entirely from fall-prevention research in older adults. The Cochrane systematic review by Sherrington *et al.* (2019) <sup>[28]</sup>, synthesising dozens of studies, confirmed that balance

training improves postural control and reduces fall incidence among community-dwelling older adults, forming the strongest evidence base for balance training. Direct extrapolation of older-adult findings to young-to-middle-aged office-workers constitutes a fundamental paradigm mismatch. Balance deterioration in older adults arises from combined neuro-muscular ageing, sensory decline and sarcopenia; falls represent clinically-significant endpoint events. By contrast, “proprioceptive degradation” among young-to-middle-aged office employees reflects functional adaptive change without clinical fall risk. Pathological mechanisms and intervention goals therefore diverge substantially.

Studies specifically investigating balance training among office-based young-to-middle-aged adults remain scarce and yield mixed outcomes. Scharf & Tilp (2023) <sup>[27]</sup> implemented a 12-week web-delivered workplace coordinative-exercise intervention incorporating balance tasks. While participants reported subjective improvements in motor skill, objective balance metrics showed no statistically-significant change; comparable trends emerged within control groups, suggesting test-learning effects may outweigh true intervention effects. Researchers argued that chronically low weekly balance-training dosage explained null findings, yet achieving therapeutically-relevant weekly training durations would severely conflict with workplace time constraints. Studies employing emerging devices such as whole-body vibration report short-term improvements in subjective balance and objective postural parameters. Nevertheless, equipment-dependent interventions have limited real-world accessibility, and sustained long-term effects remain unconfirmed. Overall, dose-response relationships, optimal training modalities and persistence of long-term benefits for workplace-dwelling young-to-middle-aged adults lack consensus.

#### 2. Reversibility of Proprioceptive Degradation

Claims that “sedentary behaviour degrades proprioception and balance training reverses it” presuppose full reversibility of proprioceptive alterations. In reality, adaptations from chronic postural habits encompass both functional and structural components.

Functional changes stem from insufficient joint-receptor stimulation and reduced central-nervous-system integration efficiency; these may improve rapidly via sensorimotor training. Structural modifications — including adaptive remodelling of muscle-spindle quantity and morphology together with mechanoreceptor reorganisation within connective tissues — demand prolonged stimulation for reversal and may prove partially permanent. Existing workplace-intervention studies apply short-term protocols (4-12 weeks), capturing only functional adaptations without demonstrating reversal of deep-seated structural change. Furthermore, proprioception and postural control do not follow simple linear relationships. Human postural regulation integrates proprioceptive, vestibular and visual inputs; deficits in one sensory modality may be compensated by others. Increased visual reliance among sedentary individuals represents one such compensatory strategy. Although balance training can reduce visual dependence and increase proprioceptive contribution, it remains unproven whether this necessarily enhances overall postural control or translates into observable improvements in real-work-setting posture.

### 3. Ecological-Validity Challenges in Workplace Settings

While promising within laboratory environments, balance training faces three layers of ecological-validity barriers upon translation to real-world offices. First, spatial constraints. Many balance exercises require adequate safe clearance. Single-leg-stance and dynamic weight-shift movements attract social attention within open-plan offices while introducing collision and fall hazards. Individual workstations typically afford limited room for complete balance-training sequences. Second, time-dosage paradoxes. As noted previously, therapeutically-effective training dosages conflict with fragmented time available within workplaces. Brief balance drills lasting 1-2 minutes every 20-30 minutes accumulate insufficient total exposure; concentrated 10-15-minute sessions are difficult to schedule amid work obligations. Workplace balance training therefore either delivers sub-therapeutic dosage or proves practically unfeasible. Third, long-term adherence decay. Balance-training movements tend to be monotonous, with diminishing marginal returns over time. Without tangible fall-risk concerns, young-to-middle-aged adults lack intrinsic motivation for sustained practice. In a 21-week training programme for office-workers with spinal dysfunction, Kalwa *et al.* (2018) documented weekly attendance rates of merely 56 % and task-completion rates of 60 %, illustrating adherence challenges within authentic workplace contexts.

Balance training theoretically supports neuro-muscular function as an adjunct to strength and aerobic conditioning. Yet contemporary workplace-health discourse frequently places it alongside stretching as a core countermeasure against sedentary behaviour, representing serious evidence misalignment. In terms of priority for young-to-middle-aged sedentary office-workers, balance training delivers lower marginal health benefits than sedentary-behaviour interruption or general aerobic activity, and is neither a first-line strategy for metabolic improvement nor for alleviating musculoskeletal discomfort. Over-allocating limited workplace-health resources toward balance training yields poor cost-effectiveness. A more appropriate positioning integrates balance elements within routine stretching and core-strength work rather than promoting independent balance-training modules. Targeted assessment and training should be reserved for selected individuals experiencing postural pain or recurrent injury. Balance training should not constitute a standard component of universal workplace exercise prescriptions but rather a precision intervention deployed conditional upon individual needs.

#### Sedentary-Behaviour Interruption: Myth versus Reality

##### 1. Spatiotemporal Boundaries of Metabolic Benefits

“Standing and moving every 20-30 minutes” represents one of the most influential recommendations within workplace-health practice. Core supporting evidence originates from short-term metabolic experiments: uninterrupted sitting suppresses skeletal-muscle lipoprotein-lipase (LPL) activity, whereas frequent brief physical-activity bouts preserve baseline LPL levels and substantially blunt post-prandial peaks in blood-glucose, insulin and triglycerides. A systematic review and meta-analysis by Loh *et al.* (2020) <sup>[17]</sup> synthesised dozens of studies confirming dose-dependent post-prandial-metabolic improvements from breaking prolonged sitting.

Three critical constraints circumscribe generalisability of these findings. First, temporal boundaries: nearly all studies observe acute effects within single-day, post-prandial-hour windows; long-term follow-up studies exceeding six months remain rare. A systematic review of “exercise-snack” interventions by Wan *et al.* (2025) <sup>[36]</sup> reported short-term improvements in cardiorespiratory fitness and selected metabolic markers, yet non-significant long-term effects for triglycerides, body weight and adiposity. Accordingly, it remains unproven whether acute post-prandial-glucose attenuation ultimately reduces long-term diabetes risk. Second, intensity boundaries: activity modality strongly modulates benefit magnitude. Movements recruiting large lower-extremity muscle groups such as stair-climbing or squats generate substantially greater haemodynamic and endothelial stimulation than simple marching-in-place or passive standing. While standing outperforms sitting, low-level muscular contraction yields only modest metabolic gains. A three-level meta-analysis by Wang *et al.* (2026) <sup>[37]</sup> demonstrated superior peripheral-vascular-function improvements from dynamic muscular contraction relative to passive standing. Current guidelines frequently obscure distinctions between interruption modalities, creating the misleading impression that “merely standing suffices”, thereby overstating health returns for minimal-intensity activity. Third, population boundaries: metabolic improvements are most pronounced among individuals with elevated BMI and insulin resistance; effect sizes shrink considerably among metabolically-healthy normal-weight adults. Interrupting sedentary behaviour delivers far greater value for high-risk subgroups than for the general healthy workforce and should not constitute a one-size-fits-all recommendation.

##### 2. Cognitive and Productivity Costs

A major blind spot within sedentary-interruption research is its near-exclusive focus on physiological health indicators while ignoring impacts on cognitive function and workplace productivity. “Breaking sedentary time” simultaneously means “breaking work”. Continuity of tasks and maintenance of deep concentration are central to occupational performance. Empirical findings regarding cognition following sedentary-behaviour interruption are mixed. Some research links brief walking breaks to increased cerebral blood-flow velocity, enhancing selective attention and working-memory. Other work highlights cognitive-switching costs associated with frequent task discontinuity that disrupt deep-work states and may impair performance on cognitively-demanding complex assignments. Quantitative analysis by Li *et al.* (2022) showed cognitive benefits from exercise breaks are restricted to specific domains and short-lived. The review by Tuckwell *et al.* (2022) <sup>[34]</sup> further noted cognitive gains typically persist fewer than 30 minutes and apply only to circumscribed cognitive functions; excessive interruption frequency may produce net cognitive costs outweighing physiological advantages.

For professions requiring deep work such as software development, writing, design and strategic analysis, mandatory interruptions every 20-30 minutes can prove highly disruptive. Cognitive-psychology research documents an average 10-15-minute transition period required to enter states of focused concentration. Repeated interruptions fragment attention, degrading output quality

and efficiency for complex assignments. Such productivity costs have never been incorporated into cost-benefit analyses for sedentary-interruption strategies. Outcomes further depend upon alignment between activity type and task requirements. Low-intensity stretching or slow walking impose minimal cognitive interference, whereas balance- or coordination-focused drills demand attentional resources and generate larger switching costs. Universal fixed-frequency interruption guidelines disregard heterogeneous cognitive demands across occupations, exemplifying de-contextualised reasoning.

### 3. Practical Paradoxes of Environmental Modification

Sit-stand workstations have been widely advocated as an environmental solution enabling sedentary-behaviour interruption. Short-term intervention studies report improved heart-rate variability, reduced subjective stress and modest productivity gains. These observations derive predominantly from early-phase follow-up; real-world long-term usage paints a contrasting picture. Longitudinal studies document marked attenuation in sit-stand-desk utilisation over time. In an RCT by Konradt *et al.* (2022) <sup>[12]</sup>, initial health benefits gradually faded (fade-out effect); employees reduced standing duration until values approximated baseline. Barriers to sustained use include lower-limb discomfort and fatigue during prolonged standing, incompatibility of standing posture with handwriting, drawing and fine-manipulation tasks, insufficient desktop space, aesthetic-usability concerns, and lack of ongoing motivation or organisational support. Qualitative research by Renaud *et al.* (2020) <sup>[26]</sup> found that even following corporate deployment of sit-stand desks, sustained long-term adoption remained low. Most employees reverted to predominantly sitting, using height-adjustment features only for occasional positional variation. Hardware investment alone therefore cannot resolve sedentary behaviour. Without accompanying managerial norms, cultural guidance and habit-formation support, costly environmental modifications risk becoming performative tokenism.

Sedentary-behaviour interruption possesses well-supported mechanistic and short-term empirical foundations for disrupting pathological cascades triggered by uninterrupted sitting. Contemporary discourse, however, frequently maximises purported benefits while minimising associated costs, portraying the strategy as cost-free health enhancement. In reality, interrupting sitting incurs tangible costs: cognitive-attention costs, workflow-disruption costs, economic costs of environmental hardware, plus psychological costs of habit modification. Cost-benefit ratios vary substantially across occupations, task profiles and health-risk strata. Frequent interruptions impose minimal burdens for fragmented-task roles such as front-line customer service or data entry, yet may yield net harm for research-and-development, creative or decision-making positions requiring sustained focus. Appropriate sedentary-interruption strategies therefore reject universal 20-30-minute alarm-triggered breaks in favour of context-flexible approaches adapted to occupational characteristics. Priority should be given to natural breaks embedded within task transitions rather than enforced task disruption; non-intentional activity augmentation (e.g. walking meetings, routine beverage-retrieval trips) is preferable to mechanical timed standing protocols.

Practitioners must honestly acknowledge adherence decay risks for environmental modifications, pairing hardware procurement with soft-management interventions.

## Exercise-Mediated Stress Reduction: Mechanistic Myths and Responsibility Displacement

### 1. Heterogeneity in HPA-Axis Modulation

“Regular exercise modulates stress and lowers cortisol” represents a tenet of workplace-health discourse. The underlying premise holds that chronic moderate-intensity exercise down-regulates HPA-axis baseline sensitivity, resetting diurnal-cortisol rhythmicity and conferring a “stress-inoculation” effect. A network meta-analysis by Li *et al.* (2025) linked mind-body exercise such as yoga to cortisol reduction. Average effect sizes mask substantial inter-individual variation, however; multiple moderating variables determine real-world stress-reduction outcomes. First, sex differences. Robust research documents divergent HPA-axis stress responsiveness by biological sex: men exhibit stronger cortisol reactivity to psychological stressors, while female responses are comparatively blunted. Exercise-stress interactions are likewise sex-specific. As summarised by Mennitti *et al.* (2024) <sup>[20]</sup>, long-term training alters baseline cortisol differently across sexes; women may experience larger cortisol reductions *yet also* greater vulnerability to over-training-related cortisol dysregulation. Second, stress-source typology. Exercise effectively buffers against controllable acute stressors yet offers limited mitigation against chronic, uncontrollable occupational stress including persistent workload overload, poor management and workplace bullying. A meta-analysis by Moyers & Hagger (2023) <sup>[21]</sup> reported larger cortisol-reducing exercise effects among individuals with elevated baseline stress, yet improvements become offset by ongoing stress exposure when root stressors persist. Third, exercise dosage and intensity. An inverted-U-shaped dose-response relationship is widely accepted, yet boundaries for “moderate intensity” remain ambiguous. Optimal weekly MET-minute ranges reflect population averages concealing multi-fold inter-individual variability. For already severely fatigued employees, mandated “moderate-intensity exercise” may itself constitute an additional stressor driving cortisol elevation. High-intensity interval training (HIIT) fails to lower cortisol and may even raise baseline concentrations — a detail frequently omitted from popular-science communications. In short, “exercise relieves stress” is not a universal law. Benefits apply only for specific subgroups, stress categories and dosage windows; outside these bounds, exercise may prove ineffective or counter-productive.

### 2. Limitations of the Endocannabinoid Hypothesis

Popular discourse has updated understandings of exercise-induced euphoria from the classic endorphin hypothesis toward the “runner’s high mediated by endocannabinoids”. In a landmark study, Siebers *et al.* (2021) <sup>[29]</sup> administered naltrexone to block opioid receptors; exercise-driven anxiolysis and euphoria persisted alongside elevated plasma endocannabinoid concentrations, challenging the dominant endorphin framework. Important boundary conditions constrain this mechanistic account. First, nearly all supporting evidence derives from single-bout acute exercise. Findings regarding endocannabinoid-system adaptations following chronic

regular training remain highly inconsistent. A systematic review and meta-analysis by Desai *et al.* (2022) <sup>[5]</sup> reported heterogeneous chronic-exercise effects on baseline anandamide concentrations: approximately one-third of studies detected significant increases, one-third significant decreases and one-third null outcomes. Heterogeneity likely arises from variation in exercise modality, intensity, duration and participant characteristics. Endocannabinoids primarily mediate short-term pleasure after single exercise bouts; it remains unclear whether long-term emotional benefits of exercise rely upon this system.

Second, exercise-related mood enhancement arises from multi-system crosstalk. Beyond endocannabinoids, dopaminergic, serotonergic, BDNF-related and endogenous-opioid pathways contribute; dominant mechanistic pathways vary by exercise modality and individual. Attributing “exercise-induced good mood” exclusively to endocannabinoids repeats the oversimplification previously seen with endorphin-centred explanations. The review by Matei *et al.* (2023) <sup>[19]</sup> emphasised that endocannabinoids constitute merely one interconnected component among multiple neurotransmitter-reward circuits. Of further concern, commercial discourse exploits these mechanistic discoveries to propagate imagery of “naturally addictive, risk-free exercise”. The endocannabinoid system is tightly coupled to reward pathways; excessive exercise may produce addiction-like behavioural patterns imposing combined psychological and physiological burdens. This potential hazard is entirely absent from contemporary exercise-stress-reduction narratives.

### 3. Ethical Risks of Responsibility Displacement

Beyond mechanistic debates lies a deeper social function embedded within exercise-stress-reduction discourse: individualisation of workplace-stress solutions and implicit displacement of organisational health responsibilities. According to social-ecological-model frameworks, workplace sedentary behaviour and stress stem from multi-level factors spanning individual, social, organisational and physical environments. Work overload, limited temporal autonomy, poor managerial practice, lack of job control and ambiguous career trajectories represent primary sources of chronic occupational stress. Ecological research by Mullane *et al.* (2017) <sup>[22]</sup> confirmed that organisational policy and workplace-culture factors exert greater influence over sedentary-behaviour patterns than individual knowledge. The narrative “if you feel stressed, exercise” shifts full problem-solving accountability onto employees: persistent anxiety, insomnia or poor health are interpreted as failures of personal discipline and insufficient exercise adherence.

Responsibility displacement carries tangible organisational consequences. Many corporations implement employee-wellness programmes and subsidise gym access while simultaneously extending working hours and amplifying performance pressure, reframing health as an individual “self-management” obligation. Exercise transforms from a health-promotion tool into a new moral duty and implicit performance metric. Critical exercise medicine does not reject stress-regulating benefits of exercise. It stresses, however, that exercise cannot substitute organisation-level stress interventions. Mitigating workload burdens, refining management workflows, safeguarding

employee autonomy and cultivating supportive organisational cultures constitute fundamental strategies for reducing occupational stress. Exercise serves only as an adjunct individual-level regulatory tool and must not become an organisational mechanism for evading accountability.

Exercise exerts genuine yet bounded, conditional and costly effects on stress and mood. Current workplace discourse universalises and absolutises these effects, propagating the cultural myth “exercise solves all distress”. This misrepresents heterogeneous scientific evidence and obscures structural origins of workplace stress. For sedentary workers, exercise-driven stress reduction should be framed as an optional personal-regulation resource rather than a mandatory health obligation. Implementation should respect individual variability, prioritise autonomous choice and moderation, and guard against “exercise-performative” norms. Most importantly, organisations must not substitute gym-facility provision for genuine labour-rights protections; health promotion should never serve as packaging for worker exploitation.

## Critical Reconstruction of Integrated Exercise Prescriptions

### 1. Interaction Effects Across Four Intervention Modules

Contemporary integrated exercise prescriptions rest upon theoretical logic that “synergistic action across four modules maintains vascular-neural-metabolic health”. Empirical investigations into interactive effects between modules remain virtually absent, however. It is unknown whether combined delivery yields supra-additive synergy, mutual interference or antagonistic outcomes. For instance, exercise-training science establishes that sequencing and intervals between static stretching and strength training modify strength-gain trajectories. Workplace prescriptions frequently combine stretching and core-strength drills arbitrarily without considering temporal arrangements influencing training efficacy. Similarly, frequent sedentary-behaviour interruption disrupting work rhythms may increase subjective stress, partially offsetting exercise-driven stress-regulatory benefits. Both balance-training and flexibility-training consume limited fragmented workplace time; simultaneous promotion may compete for attentional resources and reduce adherence for both interventions. Fundamentally, individual time, energy and motivation represent scarce resources. Layering all four intervention modules imposes escalating behavioural demands upon employees: stand every half-hour, complete stretching daily, perform weekly balance training, plus aerobic and resistance work. Growing prescription complexity inevitably lowers adherence. Existing integrated frameworks largely ignore cognitive load and behavioural costs, implicitly assuming employees’ primary priority consists of fulfilling health recommendations.

### 2. Mismatch between Evidence Grade and Recommendation Strength

The four intervention modules rest upon bodies of evidence of unequal certainty, yet most workplace guidelines grant them equivalent promotional weight. This creates misalignment between evidence grading and recommendation intensity.

Ranked from strongest to weakest supporting evidence:

1. Short-term metabolic benefits of sedentary-behaviour interruption: supported by abundant RCTs and meta-analyses, clear causal pathways and high replicability.
2. HPA-axis modulation via regular exercise: robust evidence base yet high heterogeneity with large inter-individual effect-size variation.
3. Long-term cardiovascular effects of static stretching: preliminary supporting data constrained by limited sample sizes and substantial methodological heterogeneity.
4. Balance-training benefits among young-to-middle-aged office-workers: scarce direct evidence, largely extrapolated from older-adult research with poorly-defined effect boundaries.

Recommendation strength should correspond to evidence certainty. Equivalent promotion of weakly-supported alongside strongly-supported interventions overstates the value of lower-certainty strategies and distorts resource allocation. Scientific workplace exercise prescriptions should explicitly label evidence grades for each recommendation, enabling practitioners and decision-makers to distinguish robust consensus conclusions from tentative speculative propositions.

### 3. From Individual Behaviour Change to Organisational and Environmental Support

The dominant paradigm bias shaping contemporary workplace exercise interventions lies in over-focus upon individual-behaviour modification while neglecting structural organisational-environmental determinants. Social-ecological-model perspectives hold that individual behaviours are embedded within multi-layered organisational, community and policy contexts; information campaigns and behavioural persuasion achieve minimal impact without supportive environments. A scoping review by Garne-Dalgaard *et al.* (2019) <sup>[8]</sup> concluded that success or failure of workplace-physical-activity interventions hinges not upon exercise-programme design itself but upon organisation-level enabling strategies. Organisational support includes at minimum:

- **Temporal support:** flexible working hours, formal work-break policies, counting activity time within contracted working hours.
- **Spatial support:** adequate activity space, suitable changing-room and shower amenities, rational workstation layouts.
- **Cultural support:** managerial role-modelling, dismantling norms framing “moving around” as slacking off, promoting walking-meetings.
- **Policy support:** reasonable workload standards, overtime-control mechanisms, balanced appraisal metrics accounting for both performance and employee well-being.

Most corporate workplace-health initiatives remain superficial: distributing pamphlets, hosting lectures or issuing gym membership vouchers, effectively shifting responsibility toward individuals. Transformative structural changes — shortening working hours, reducing unnecessary meetings and enhancing employee job autonomy — are typically excluded from health-promotion agendas because they challenge core organisational interests. Health

promotion that discusses exercise exclusively while ignoring working conditions is destined for limited effectiveness.

### 4. Missing Localised Research and Cultural-Fit Considerations

The overwhelming majority of available studies originate from Western populations. Direct application of their conclusions within Chinese-cultural workplace contexts raises concerns over cultural compatibility. Chinese-context workplaces feature distinctive contextual traits: longer working hours, pervasive overtime culture, high presenteeism prevalence, pronounced collectivist norms, plus unique lunch-break and dietary patterns. For example, mid-day physical-activity routines commonplace in Western contexts may conflict with lunch-nap cultural norms within Chinese-language-region workplaces. Publicly performing stretching movements at work may trigger social discomfort contradicting prevailing workplace norms of modesty. Collectivist cultural contexts may generate social-pressure penalties for individuals undertaking physical activity separately from colleagues. These cultural-context variables markedly modify intervention adherence and outcomes. Furthermore, sedentary patterns and physical-activity access differ sharply across industries, hierarchical strata and income brackets. Junior administrative and outsourced staff possess far lower control over work time and physical workspace, rendering sedentary-interruption protocols harder to implement; senior managers typically enjoy greater resources and temporal flexibility. Health-promotion strategies disregarding such stratification risks amplifying health inequities.

### 5. Tiered Management of Safety and Risk

Current safety guidance tends toward over-generalisation. Caveats such as “consult a physician if pre-existing medical conditions apply” deliver minimal actionable guidance. Risk-benefit ratios for exercise interventions diverge across health-status subgroups and demand stratified risk management. For instance, breath-holding-associated stretching may precipitate dangerous blood-pressure spikes among persons with uncontrolled hypertension; excessive stretching may exacerbate symptoms for individuals with degenerative joint disorders; over-exertion can worsen symptomatology for chronic-fatigue-syndrome patients. For such vulnerable subgroups, exercise modality, intensity, timing and frequency all require individualised adjustment. Workplace exercise prescriptions should avoid one-size-fits-all outputs and instead deliver tiered protocols: baseline-level protocols suitable for all generally-healthy employees, advanced-level protocols for persons presenting specific risk factors, and rehabilitation-oriented protocols for individuals with established clinical disease. Clear red-flag symptom criteria and medical-referral pathways must be embedded to prevent panacea-like framing of exercise from delaying appropriate clinical care.

### Conclusions

Through systematic appraisal of four major exercise-intervention modules, this paper draws three central critical conclusions: First, intervention mechanisms and benefits are commonly over-estimated, while boundaries and risks are systematically overlooked. Cardiovascular effects of static stretching exhibit

methodological heterogeneity; acute force-suppression and over-stretching-injury risks remain under-reported. Evidence for balance training is inappropriately extrapolated from older-adult populations to young-to-middle-aged office-workers. Metabolic gains from sedentary-behaviour interruption are limited to acute short-term experimental contexts; cognitive-productivity costs have not been incorporated into evaluation frameworks (OpenAI, 2026). Exercise-driven HPA-axis modulation displays substantial inter-individual heterogeneity, and endocannabinoid-related mechanistic evidence is restricted to acute observations. Second, biomedical reductionism prevails while social and organisational contexts are neglected. Contemporary workplace exercise medicine reduces health challenges to individual physiological anomalies, framing solutions purely in terms of individual-behaviour change while abstracting away workplace organisational structures, occupational cultures, power dynamics and social inequities. This not only constrains intervention effectiveness but also introduces ethical risks associated with responsibility displacement. Third, evidence-recommendation misalignment and poor ecological validity persist. Interventions supported by disparate-certainty evidence receive equivalent practical emphasis. Most studies originate within controlled laboratory settings disconnected from real-world workplace complexity, producing the widespread phenomenon: “interventions prove efficacious in research yet deliver minimal real-world benefit”. Building upon these critiques, three shifts are required within future workplace-exercise-medicine scholarship and practice: First, moving from validation-oriented toward critical-oriented research. Beyond investigating “what works”, researchers must examine “for whom interventions work, under what contextual conditions, what costs are incurred, and where boundaries lie”. Increased attention should target adverse intervention outcomes, unintended consequences and formal cost-benefit analysis. Non-exercise comparison groups should be deployed to avoid self-fulfilling prophecies favouring exercise interventions. Second, expanding analytical scope from individual-level toward social-ecological-level enquiry. Research horizons should extend beyond individual physiology to encompass organisational, community and policy-level influences. Investigations should evaluate health returns for organisation-level interventions (e.g. flexible-working-time schemes, meeting-practice reform, workload governance), rather than perpetuating demands exclusively for employee behavioural modification. Third, transitioning from de-contextualised toward locally-embedded knowledge production. Large-sample long-term follow-up studies situated within local-cultural workplace contexts are needed. Exercise prescriptions adapted to local physical characteristics, working habits and social norms should be developed (Lu, 2026). Research must attend to health disparities across occupations and socioeconomic strata to advance more equitable workplace-health policies. Exercise undoubtedly constitutes an important health-promotion tool, yet it is neither omnipotent nor cost-free. For sedentary working-age populations, genuine health solutions entail far more than “teaching employees how to move”. They require “building work environments that enable physical activity”. The value of critical exercise-medicine perspectives lies in puncturing popular “exercise-as-panacea” discourse, exposing

structural determinants underpinning workplace health and facilitating pursuit of more authentic, equitable and sustainable workplace well-being.

## References

1. Arntz F, Markov A, Behm DG, Behrens M, Negra Y, Nakamura M, *et al.* Chronic effects of static stretching exercises on muscle strength and power in healthy individuals across the lifespan: A systematic review with multi level meta analysis. *Sports Medicine*,2023;53(3):723 745. <https://doi.org/10.1007/s40279-022-01806-9>
2. Bates LC, Alansare A, Gibbs BB, Hanson ED, Stoner L. Effects of acute prolonged sitting and interrupting prolonged sitting on heart rate variability and heart rate in adults: A meta analysis. *Frontiers in Physiology*,2021;12:664628. <https://doi.org/10.3389/fphys.2021.664628>
3. Bull FC, Al Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, *et al.* World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*,2020;54(24):1451 1462. <https://doi.org/10.1136/bjsports-2020-102955>
4. Dempsey PC, Owen N, Yates TE, Kingwell BA, Dunstan DW. Sitting less and moving more: Improved glycaemic control for type 2 diabetes prevention and management. *Current Diabetes Reports*,2016;16(11):114. <https://doi.org/10.1007/s11892-016-0797-4>
5. Desai S, Borg B, Cuttler C, Crombie KM, Rabinak CA, Hill MN, *et al.* A systematic review and meta analysis on the effects of exercise on the endocannabinoid system. *Cannabis and Cannabinoid Research*,2022;7(4):388 408. <https://doi.org/10.1089/can.2021.0113>
6. Dobias J, Říha M. Gastrocnemius muscle rupture related to stretching in spastic paresis: A case report. *American Journal of Physical Medicine & Rehabilitation*,2025;104(12):e180–e182. <https://doi.org/10.1097/PHM.0000000000002864>
7. Dunstan DW, Kingwell BA, Larsen R, Healy GN, Cerin E, Hamilton MT, *et al.* Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care*,2012;35(5):976 983. <https://doi.org/10.2337/dc11-1931>
8. Garne Dalgaard A, Mann S, Bredahl TVG, Stochkendahl MJ. Implementation strategies, and barriers and facilitators for implementation of physical activity at work: A scoping review. *Chiropractic & Manual Therapies*,2019;27:48. <https://doi.org/10.1186/s12998-019-0268-5>
9. Han M, Li X. Acute effects of interrupting prolonged sitting with short bouts of physical activity on postprandial metabolism in sedentary adults: A multi level meta analysis. *Public Health*,2026;259:106449. <https://doi.org/10.1016/j.puhe.2026.106449>
10. Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, Zimmet PZ, *et al.* Breaks in sedentary time: Beneficial associations with metabolic risk. *Diabetes Care*,2008;31(4):661 666. <https://doi.org/10.2337/dc07-2046>
11. Kałwa M, Ostrowska B, Żywień U, Stefaniak T. Workplace exercises: Improvement of postural stability of office workers with spine dysfunctions following a

- 21 week health training programme. *Baltic Journal of Health and Physical Activity*,2018;10(4):119 130. <https://doi.org/10.29359/BJHPA.10.4.11>
12. Konradt U, Nath A, Kryś S, Heblich F. Longitudinal effects of a sit stand desk intervention Persistence, fade out, and psychological momentum: A randomized controlled trial. *BMC Psychology*,2022;10:246. <https://doi.org/10.1186/s40359 022 00948 9>
13. Kruse NT, Scheuermann BW. Cardiovascular responses to skeletal muscle stretching: “Stretching” the truth or a new exercise paradigm for cardiovascular medicine? *Sports Medicine*,2017;47(12):2507 2520. <https://doi.org/10.1007/s40279 017 0768 1>
14. Larsen RN, Kingwell BA, Sethi P, Cerin E, Owen N, Dunstan DW. Breaking up prolonged sitting reduces resting blood pressure in overweight/obese adults. *Nutrition, Metabolism and Cardiovascular Diseases*,2014;24(9):976 982. <https://doi.org/10.1016/j.numecd.2014.04.011>
15. Li J, Herold F, Ludyga S, Yu Q, Zhang X, Zou L. The acute effects of physical exercise breaks on cognitive function during prolonged sitting: The first quantitative evidence. *Complementary Therapies in Clinical Practice*,2022;48:101594. <https://doi.org/10.1016/j.ctcp.2022.101594>
16. Li X, Huang J, Zhu F. The optimal exercise modality and dose for cortisol reduction in psychological distress: A systematic review and network meta analysis. *Sports*,2025;13(12):415. <https://doi.org/10.3390/sports13120415>
17. Loh R, Stamatakis E, Folkerts D, Allgrove JE, Moir HJ. Effects of interrupting prolonged sitting with physical activity breaks on blood glucose, insulin and triacylglycerol measures: A systematic review and meta analysis. *Sports Medicine*,2020;50(2):295 330. <https://doi.org/10.1007/s40279 019 01183 w>
18. Lu L. The history of Western holistic health development. AkiNik Publications, 2026.
19. Matei D, Trofin D, Iordan DA, Onu I, Condurache I, Ionite C, *et al.* The endocannabinoid system and physical exercise. *International Journal of Molecular Sciences*,2023;24(3):1989. <https://doi.org/10.3390/ijms24031989>
20. Mennitti C, Farina G, Imperatore A, De Fonzo G, Gentile A, La Civita E, *et al.* How does physical activity modulate hormone responses? *Biomolecules*,2024;14(11):1418. <https://doi.org/10.3390/biom14111418>
21. Moyers SA, Hagger MS. Physical activity and cortisol regulation: A meta analysis. *Biological Psychology*,2023;179:108548. <https://doi.org/10.1016/j.biopsycho.2023.108548>
22. Mullane SL, Toledo MJL, Rydell SA, Feltes LH, Vuong B, Crespo NC, *et al.* Social ecological correlates of workplace sedentary behavior. *International Journal of Behavioral Nutrition and Physical Activity*,2017;14:117. <https://doi.org/10.1186/s12966 017 0576 x>
23. OpenAI. ChatGPT (GPT 5.6) [Large language model], 2026. <https://chatgpt.com/>
24. Pšeničnik Sluga S, Kozinc Ž. Sensorimotor and proprioceptive exercise programs to improve balance in older adults: A systematic review with meta analysis. *European Journal of Translational Myology*,2024;34(1):12010. <https://doi.org/10.4081/ejtm.2024.12010>
25. Quan M, Xun P, Wu H, Wang J, Cheng W, Cao M, *et al.* Effects of interrupting prolonged sitting on postprandial glycemia and insulin responses: A network meta analysis. *Journal of Sport and Health Science*,2021;10(4):419 429. <https://doi.org/10.1016/j.jshs.2020.12.006>
26. Renaud LR, Speklé EM, van der Beek AJ, van der Ploeg HP, Pasman HR, Huysmans MA. The user and non user perspective: Experiences of office workers with long term access to sit stand workstations. *PLOS ONE*,2020;15(7):e0236582. <https://doi.org/10.1371/journal.pone.0236582>
27. Scharf C, Tilp M. Twelve weeks of web based low to moderate physical activity breaks with coordinative exercises at the workplace increase motor skills but not motor abilities in office workers A randomised controlled pilot study. *International Journal of Environmental Research and Public Health*,2023;20(3):2193. <https://doi.org/10.3390/ijerph20032193>
28. Sherrington C, Fairhall NJ, Wallbank GK, Tiedemann A, Michaleff ZA, Howard K, *et al.* Exercise for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*,2019;2019(1):CD012424. <https://doi.org/10.1002/14651858.CD012424.pub2>
29. Siebers M, Biedermann SV, Bindila L, Lutz B, Fuss J. Exercise induced euphoria and anxiolysis do not depend on endogenous opioids in humans. *Psychoneuroendocrinology*,2021;126:105173. <https://doi.org/10.1016/j.psyneuen.2021.105173>
30. Tantimonaco M, Ceci R, Sabatini S, Catani MV, Rossi A, Gasperi V, *et al.* Physical activity and the endocannabinoid system: An overview. *Cellular and Molecular Life Sciences*,2014;71(14):2681 2698. <https://doi.org/10.1007/s00018 014 1575 6>
31. Themistocleous IC, Michael C, Hadjisavvas S, Papamichael E, Efstathiou MA, Michailidou C, *et al.* Effects of different types of stretching on hypertension: A systematic review with exploratory meta analysis. *Journal of Functional Morphology and Kinesiology*,2026;11(2):164. <https://doi.org/10.3390/jfkm11020164>
32. Thosar SS, Bielko SL, Mather KJ, Johnston JD, Wallace JP. Effect of prolonged sitting and breaks in sitting time on endothelial function. *Medicine & Science in Sports & Exercise*,2015;47(4):843 849. <https://doi.org/10.1249/MSS.0000000000000479>
33. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer Cheung AE, *et al.* Sedentary Behavior Research Network (SBRN) Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*,2017;14:75. <https://doi.org/10.1186/s12966 017 0525 8>
34. Tuckwell GA, Vincent GE, Gupta CC, Ferguson SA. Does breaking up sitting in office based settings result in cognitive performance improvements which last throughout the day? A review of the evidence. *Industrial Health*,2022;60(6):501 513. <https://doi.org/10.2486/indhealth.2021 0174>

35. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all cause mortality risk in 222 497 Australian adults. *Archives of Internal Medicine*,2012;172(6):494–500.  
<https://doi.org/10.1001/archinternmed.2011.2174>
36. Wan KW, Dai ZH, Wong PS, Huang WY, Lei EFC, Little JP, *et al.* Effects of exercise snacks on cardiometabolic health and body composition in adults: A systematic review and meta analysis. *Scandinavian Journal of Medicine & Science in Sports*,2025;35(8):e70114.  
<https://doi.org/10.1111/sms.70114>
37. Wang H, Chang Y, Wang H, Diao K, Sun S. Acute effects of “exercise snacks” during prolonged sitting on hemodynamics and peripheral vascular function: A three level meta analysis. *Nutrition & Metabolism*,2026;23(1):61.  
<https://doi.org/10.1186/s12986-026-01120-5>
38. Warneke K, Thomas E, Blazeovich AJ, Afonso J, Behm DG, Marchetti PH, *et al.* Practical recommendations on stretching exercise: A Delphi consensus statement of international research experts. *Journal of Sport and Health Science*,2025;14:101067.  
<https://doi.org/10.1016/j.jshs.2025.101067>
39. Wen D, Utesch T, Wu J, Robertson S, Liu J, Hu G, *et al.* Effects of different protocols of high intensity interval training for VO<sub>2</sub>max improvements in adults: A meta analysis of randomised controlled trials. *Journal of Science and Medicine in Sport*,2019;22(8):941–947.  
<https://doi.org/10.1016/j.jsams.2019.01.013>