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Impact of Sedentary Behavior on Metabolic Health in Adults: A Narrative Review

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Abstract

Background. Sedentary behavior is an independent determinant of metabolic health. Prolonged sitting is associated with insulin resistance, dyslipidemia, obesity, metabolic syndrome, and type 2 diabetes, even in physically active individuals. **Aim**. To synthesize evidence on the impact of sedentary behavior on metabolic health in adults, including epidemiological

associations, mechanisms, and intervention effects. **Material and methods**. A systematic narrative review was conducted using PubMed and reference screening. Studies evaluating sedentary behavior and metabolic outcomes in adults were included. Due to heterogeneity, findings were synthesized thematically. **Results**. Higher sedentary time was consistently associated with adverse metabolic profiles, particularly impaired glucose metabolism and increased diabetes risk. Experimental studies show that interrupting sitting improves glucose and insulin responses. Mechanistic evidence supports links with reduced muscle activity and insulin sensitivity. Evidence for lipid profile and obesity is less consistent, and long-term intervention data remain limited. **Conclusions**. Sedentary behavior is a modifiable risk factor for metabolic dysfunction. Reducing and interrupting sitting should complement physical activity. Further studies should use standardized measures and clinically relevant endpoints.

Key words: sedentary behavior, metabolic health, type 2 diabetes, metabolic syndrome, physical activity.

Introduction

Sedentary behavior has emerged as a distinct and increasingly important determinant of metabolic health in modern societies. Defined as any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents while in a sitting, reclining, or lying posture, sedentary behavior is conceptually and physiologically different from physical inactivity, which refers to insufficient engagement in moderate-to-vigorous physical activity (Tremblay et al., 2017). This distinction is critical, as individuals may meet recommended physical activity guidelines yet still accumulate prolonged periods of sedentary time, thereby exposing themselves to independent metabolic risks.

Over recent decades, technological advancements and shifts toward desk-based occupations have led to a marked increase in sedentary time across adult populations. Epidemiological data indicate that adults spend a substantial proportion of their waking hours engaged in sedentary behaviors, often exceeding 8–10 hours per day (Matthews et al., 2016; Prince et al., 2020). Concurrently, the global burden of metabolic disorders, including type 2 diabetes mellitus and metabolic syndrome, has risen dramatically, with recent global modelling showing a substantial increase in metabolic syndrome prevalence between 2000 and 2023 (Noubiap et al., 2025),

highlighting the need to identify modifiable behavioral risk factors beyond traditional lifestyle determinants. In addition, sedentary time appears highly prevalent among individuals with diabetes and metabolic syndrome, further supporting its relevance as a target for metabolic risk reduction (Salari et al., 2024).

A growing body of evidence has demonstrated consistent associations between sedentary behavior and adverse metabolic outcomes. Cross-sectional analyses from large population-based cohorts have shown that increased sedentary time is associated with unfavorable cardiometabolic biomarker profiles, including elevated waist circumference, triglycerides, and insulin levels, alongside reduced high-density lipoprotein cholesterol (Healy et al., 2011). Importantly, these associations persist after adjustment for moderate-to-vigorous physical activity, suggesting that sedentary behavior exerts independent effects on metabolic regulation (Healy et al., 2011; Lavie et al., 2019).

Longitudinal and prospective cohort studies further support the role of sedentary behavior as a predictor of clinically relevant outcomes. Increased duration of sedentary activities, particularly television viewing, has been associated with a higher risk of incident type 2 diabetes, with dose-dependent relationships observed across populations (Bao et al., 2014). In high-risk groups, such as individuals with prediabetes, increased sedentary time has been linked to progression toward overt diabetes, with measurable increases in risk associated with each additional hour of sedentary exposure (Rockette-Wagner et al., 2015). These findings underscore the importance of sedentary behavior not only as a correlate but also as a potential driver of metabolic disease development.

Mechanistic insights provide biological plausibility for these associations. Prolonged inactivity of skeletal muscle leads to suppression of key metabolic processes, including lipoprotein lipase activity and glucose uptake, resulting in impaired lipid metabolism and reduced insulin sensitivity (Hamilton et al., 2014). Notably, these metabolic alterations can occur independently of moderate-to-vigorous physical activity, emphasizing the unique physiological consequences of uninterrupted sedentary time.

Experimental studies have further demonstrated that even short interruptions of sitting with light-intensity activity can significantly improve postprandial glucose and insulin responses, supporting a causal relationship between sedentary patterns and metabolic dysfunction (Dunstan et al., 2012; Peddie et al., 2013). These findings highlight the importance not only of total sedentary time but also of its distribution throughout the day.

Despite the growing recognition of sedentary behavior as a health risk, important uncertainties remain regarding its interaction with physical activity and its modifiability. While higher levels of physical activity are associated with reduced metabolic risk, emerging evidence suggests that they may attenuate—but not fully eliminate—the adverse effects of prolonged sitting (Lavie et al., 2019; Matthews et al., 2016). Furthermore, intervention studies indicate that strategies targeting reductions in sedentary time, in addition to increasing physical activity, may yield clinically meaningful improvements in metabolic health outcomes, although the magnitude of these effects varies across populations and study designs.

Given these considerations, a comprehensive synthesis of the available evidence is warranted to clarify the role of sedentary behavior in the development of metabolic disorders. The aim of this review is to critically evaluate the epidemiological, mechanistic, and interventional evidence linking sedentary behavior to metabolic health in adults, with particular emphasis on its independent effects, dose–response relationships, and potential for modification through behavioral interventions.

Research materials and methods

Study selection

This study is a narrative literature review analyzing previously published research on the impact of sedentary behavior on metabolic health in adults. Sedentary behavior was defined as any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents while in a sitting, reclining, or lying posture (Tremblay et al., 2017).

Inclusion criteria

Studies were included if they met all of the following criteria:

1. Investigated sedentary behavior (e.g., sitting time, screen time, prolonged inactivity) as a primary exposure variable
2. Included adult populations (≥18 years)
3. Reported metabolic health outcomes, including at least one of the following:
    - metabolic syndrome
    - insulin resistance or glucose metabolism

    - type 2 diabetes mellitus
    - lipid profile (HDL, LDL, triglycerides)
    - obesity or body composition parameters
4. Used one of the following study designs:
    - observational studies (cross-sectional or cohort)
    - randomized controlled trials
    - systematic reviews or meta-analyses
5. Were published in peer-reviewed journals between 2010 and 2025
6. Were available as full-text open-access articles
7. Provided quantitative or clearly interpretable outcomes related to sedentary behavior

Exclusion criteria

Studies were excluded if they met any of the following:

1. Focused exclusively on physical activity without assessing sedentary behavior
2. Included only children or adolescent populations (<18 years)
3. Were non-original research, including editorials, commentaries, letters to the editor, conference abstracts without full data
4. Did not report relevant metabolic outcomes
5. Used unclear or non-standard definitions of sedentary behavior
6. Were not available in full-text format
7. Were published in languages other than English

Procedure / Data sources and search strategy

A literature search was conducted primarily using PubMed, supplemented by manual reference screening and verification through publisher websites and DOI links. The search strategy was

designed to ensure transparency and reproducibility and was broadly aligned with established principles for reporting literature reviews.

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords to maximize sensitivity and specificity. The primary search query was:

("Sedentary Behavior"[MeSH] OR "sedentary behavior" OR "sedentary lifestyle" OR "sitting time" OR "prolonged sitting")
AND
("Metabolic Syndrome"[MeSH] OR "Insulin Resistance"[MeSH] OR "Diabetes Mellitus, Type 2"[MeSH] OR "metabolic health" OR "cardiometabolic risk")
AND
("Adult"[MeSH] OR adults OR "middle-aged" OR elderly)

Additional targeted searches were performed to identify:

- mechanistic studies (e.g., skeletal muscle metabolism, lipoprotein lipase activity)
- randomized controlled trials examining interruption of sedentary time
- prospective cohort studies evaluating incident metabolic outcomes

Reference lists of included articles were also manually screened to identify additional relevant studies.

Data collection and analysis / Statistical analysis

Data extraction

From each included study, the following data were extracted: study design (cross-sectional, cohort, randomized controlled trial, meta-analysis), population characteristics, method of sedentary behavior assessment (self-report vs objective measurement), metabolic outcomes measured, key results and effect sizes.

Statistical methods / synthesis approach

Due to heterogeneity in study designs, populations, and outcome measures, a quantitative meta-analysis was not performed. Instead, a thematic synthesis approach was used. Findings were

compared qualitatively, with emphasis on consistency of associations, magnitude of reported effects, independence from physical activity, clinical relevance of outcomes.

Research results

Epidemiological and cross-sectional evidence

A substantial body of epidemiological evidence demonstrates a consistent association between sedentary behavior and adverse metabolic profiles in adult populations. Cross-sectional analyses from large population-based cohorts have shown that increased sedentary time is associated with higher waist circumference, elevated triglyceride levels, reduced high-density lipoprotein (HDL) cholesterol, and impaired glucose metabolism (Healy et al., 2011). More recent evidence suggests that not only the total amount of sedentary time but also its behavioral and ecological context may be relevant, with leisure-time sedentary behavior showing associations with glucose, total cholesterol, and LDL cholesterol in young adults (Romanzini et al., 2025).

Importantly, these associations remain significant after adjustment for moderate-to-vigorous physical activity, suggesting that sedentary behavior exerts an independent effect on metabolic health (Healy et al., 2011; Lavie et al., 2019). Meta-analytic evidence further supports these findings, indicating that prolonged sedentary time is associated with a significantly increased risk of type 2 diabetes and cardiovascular disease, with risk estimates approaching a twofold increase in diabetes incidence among highly sedentary individuals (Wilmot et al., 2012).

Prospective cohort studies and clinical outcomes

Longitudinal studies provide stronger evidence for a causal relationship between sedentary behavior and metabolic disease development. In large prospective cohorts, higher levels of sedentary behavior, particularly television viewing, have been associated with a significantly increased risk of type 2 diabetes (Bao et al., 2014).

For example, individuals engaging in ≥20 hours of television viewing per week exhibited a markedly higher risk of developing type 2 diabetes compared to those with lower exposure (Bao et al., 2014). Similarly, intervention cohort data from the Diabetes Prevention Program demonstrated that each additional hour of daily sedentary behavior was associated with an

approximately 3.5% increase in diabetes risk, independent of physical activity levels (Rockette-Wagner et al., 2015).

Objective measurement studies further support these findings. In longitudinal analyses using combined heart rate and accelerometry, increases in sedentary time were associated with worsening cardiometabolic parameters, including significant increases in waist circumference over time (Lamb et al., 2015).

Mechanistic and physiological evidence

Mechanistic studies provide biological plausibility for the observed epidemiological associations. Prolonged sedentary behavior leads to reduced skeletal muscle contractile activity, resulting in suppression of key metabolic pathways, particularly lipoprotein lipase (LPL) activity (Hamilton et al., 2014).

Reduced LPL activity contributes to impaired triglyceride metabolism and decreased HDL cholesterol levels (Hamilton et al., 2014; Aadland et al., 2013). Additionally, sedentary behavior reduces insulin-stimulated glucose uptake in skeletal muscle, promoting insulin resistance (Hamilton et al., 2014).

These metabolic disturbances occur independently of moderate-to-vigorous physical activity, reinforcing the concept that sedentary behavior represents a distinct physiological risk factor (Hamilton et al., 2014). Furthermore, sedentary behavior has been linked to low-grade inflammation and endothelial dysfunction, contributing to the development of metabolic syndrome and cardiovascular disease (Lavie et al., 2019).

Experimental and intervention studies

Experimental studies have provided direct evidence supporting the causal role of sedentary behavior in metabolic dysregulation. Randomized controlled trials have demonstrated that interrupting prolonged sitting with short bouts of light-intensity activity significantly improves postprandial glucose and insulin responses (Dunstan et al., 2012; Peddie et al., 2013).

For example, breaking sitting time at regular intervals resulted in lower glucose excursions and improved insulin sensitivity compared to uninterrupted sitting (Dunstan et al., 2012). Additionally, frequent short activity breaks were shown to be more effective in improving metabolic outcomes than a single continuous bout of exercise (Peddie et al., 2013).

Longer-term intervention studies have demonstrated that reducing sedentary time can improve fasting insulin levels and other metabolic markers; however, effects on insulin sensitivity are variable, suggesting that sedentary reduction alone may not fully reverse metabolic dysfunction without additional lifestyle changes (Sjöros et al., 2023).

Dose–response relationships and interaction with physical activity

Evidence suggests a clear dose–response relationship between sedentary behavior and metabolic risk. Individuals engaging in prolonged sedentary time (≥8–10 hours per day) exhibit significantly higher risks of metabolic syndrome, type 2 diabetes, and mortality (Matthews et al., 2016).

Importantly, the interaction between sedentary behavior and physical activity has been extensively investigated. Higher levels of physical activity are associated with reduced metabolic risk; however, this protective effect is incomplete. Sedentary behavior remains associated with adverse outcomes even among physically active individuals (Lavie et al., 2019).

Substitution analyses further demonstrate that replacing sedentary time with even light-intensity activity is associated with improved metabolic outcomes (Matthews et al., 2016), reinforcing the importance of behavioral modification strategies targeting both reductions in sedentary time and increases in overall physical activity.

Discussion

The present review synthesizes epidemiological, mechanistic, and interventional evidence demonstrating that sedentary behavior is an important and independent determinant of metabolic health in adults. Across study designs, sedentary time shows consistent associations with adverse metabolic outcomes, including insulin resistance, dyslipidemia, central obesity, and increased risk of type 2 diabetes. Importantly, these associations persist after adjustment for moderate-to-vigorous physical activity, supporting the concept that sedentary behavior

represents a distinct behavioral risk factor rather than merely the absence of exercise (Healy et al., 2011; Lavie et al., 2019).

A key strength of the current evidence base lies in the convergence of findings from cross-sectional and longitudinal studies. While cross-sectional analyses demonstrate robust associations between sedentary time and unfavorable cardiometabolic profiles, prospective cohort studies provide stronger support for a causal relationship. In particular, large-scale longitudinal data indicate that prolonged sedentary behavior, especially television viewing, is associated with a significantly increased risk of incident type 2 diabetes (Bao et al., 2014). Similarly, findings from intervention cohorts, such as the Diabetes Prevention Program, show that increases in sedentary time are associated with incremental increases in diabetes risk, even in high-risk populations (Rockette-Wagner et al., 2015). These findings collectively suggest that sedentary behavior contributes not only to metabolic dysregulation but also to disease progression.

However, the magnitude of these associations varies across studies, reflecting differences in measurement methods, study populations, and definitions of sedentary behavior. For example, studies using self-reported measures of sedentary time may underestimate true exposure compared to objective assessments such as accelerometry, potentially attenuating observed associations (Prince et al., 2020). In contrast, objective measurement studies have demonstrated stronger and more consistent relationships between sedentary time and metabolic risk factors, highlighting the importance of methodological considerations in interpreting the literature (Lamb et al., 2015).

Mechanistic evidence provides a plausible biological explanation for the observed epidemiological associations. Prolonged sedentary behavior is characterized by reduced skeletal muscle activity, leading to suppression of lipoprotein lipase activity and impaired lipid metabolism (Hamilton et al., 2014). This results in elevated circulating triglycerides and reduced HDL cholesterol levels, both of which are key components of metabolic syndrome (Aadland et al., 2013). Additionally, reduced muscle contraction leads to decreased glucose uptake and impaired insulin sensitivity, contributing to the development of insulin resistance. Notably, these physiological changes occur independently of moderate-to-vigorous physical activity, reinforcing the notion that sedentary behavior exerts unique metabolic effects (Hamilton et al., 2014).

Experimental studies further strengthen the causal inference between sedentary behavior and metabolic dysfunction. Randomized controlled trials have consistently demonstrated that interrupting prolonged sitting with brief bouts of light-intensity activity improves postprandial glucose and insulin responses (Dunstan et al., 2012; Peddie et al., 2013). These findings are particularly important, as they suggest that relatively simple behavioral modifications, such as standing or light walking breaks, can yield measurable metabolic benefits. Moreover, evidence indicating that frequent short interruptions of sedentary time may be more effective than a single continuous bout of exercise challenges traditional exercise paradigms and emphasizes the importance of movement patterns throughout the day.

Despite these findings, intervention studies also reveal important limitations. While reductions in sedentary time are associated with improvements in certain metabolic markers, such as fasting insulin, the effects on insulin sensitivity and long-term clinical outcomes are less consistent (Sjöros et al., 2023). This suggests that reducing sedentary behavior alone may not be sufficient to fully reverse metabolic dysfunction and should be combined with increases in physical activity and other lifestyle modifications. Additionally, there is limited long-term randomized evidence evaluating the sustained impact of sedentary behavior reduction on hard clinical endpoints, such as incident diabetes or cardiovascular events.

An important aspect of the current literature is the interaction between sedentary behavior and physical activity. While higher levels of physical activity are associated with reduced metabolic risk, evidence indicates that this protective effect is incomplete. High levels of physical activity may attenuate, but do not fully eliminate, the adverse metabolic and mortality risks associated with prolonged sedentary behavior (Lavie et al., 2019; Matthews et al., 2016). This finding has important clinical implications, as it suggests that meeting physical activity guidelines alone may not be sufficient to mitigate the health risks associated with excessive sitting.

From a public health perspective, these findings support a dual-behavior approach to metabolic health promotion. Interventions should aim not only to increase physical activity but also to reduce total sedentary time and encourage regular interruptions of prolonged sitting. Even modest behavioral changes, such as replacing sedentary time with light-intensity activity, may lead to meaningful improvements in metabolic outcomes (Matthews et al., 2016). Given the high prevalence of sedentary behavior in modern societies, such interventions have the potential to yield substantial population-level health benefits.

Several limitations of the current evidence base should be acknowledged. First, heterogeneity in study design and measurement methods complicates direct comparison across studies. Second, reliance on self-reported sedentary behavior in many epidemiological studies introduces the potential for measurement bias. Third, most randomized controlled trials are of relatively short duration and focus on surrogate metabolic outcomes rather than long-term clinical endpoints. Finally, residual confounding cannot be entirely excluded in observational studies, particularly with respect to dietary factors and socioeconomic status.

Conclusions

Sedentary behavior represents a significant and independent determinant of metabolic health in adults. The evidence synthesized in this review demonstrates consistent associations between prolonged sedentary time and adverse metabolic outcomes, including insulin resistance, dyslipidemia, central obesity, and an increased risk of type 2 diabetes. These associations are supported by epidemiological, mechanistic, and interventional studies, collectively indicating that sedentary behavior contributes to both the development and progression of metabolic disorders.

Importantly, sedentary behavior exerts its effects independently of moderate-to-vigorous physical activity, suggesting that reducing sedentary time should be considered a distinct target in strategies aimed at improving metabolic health. While higher levels of physical activity may attenuate the adverse effects of prolonged sitting, they do not fully eliminate associated risks, underscoring the need for a comprehensive behavioral approach.

From a clinical and public health perspective, interventions should focus not only on increasing physical activity but also on reducing total sedentary time and promoting regular interruptions of prolonged sitting. Even modest changes, such as replacing sedentary time with light-intensity activity, may yield meaningful metabolic benefits.

Future research should prioritize long-term randomized studies evaluating the impact of sedentary behavior reduction on hard clinical outcomes, including type 2 diabetes and cardiovascular disease. Additionally, standardized measurement approaches are needed to improve comparability across studies and strengthen the evidence base.

In conclusion, addressing sedentary behavior represents a critical and modifiable component of metabolic disease prevention, warranting greater emphasis in both clinical practice and public health guidelines.

Disclosure

The authors declare that this manuscript is an original work and has not been published previously nor is it under consideration for publication elsewhere.

Supplementary Materials

No supplementary materials are associated with this article.

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Conflicts of Interest

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Declaration of AI

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