

Investigating The Relationship Between Long-Term Lifestyle Factors And Risk Of Developing Type 2 Diabetes Mellitus

¹Dr. Jay Raulji , ¹Dr. Dhruvin Thakor , ²Dr. Smita Manjavkar , ³Dr. Sourav Virmani

^{1,3} Post-Graduate Resident, Department Of Medicine , Sgt Medical College, Hospital And Research Institute.

²Professor, Department Of Medicine , Sgt Medical College, Hospital And Research Institute.

Abstract

Introduction: The study addresses the escalating global challenge of Type 2 Diabetes Mellitus (T2DM), attributing its rise to a complex interplay of genetic, environmental, and lifestyle factors. It emphasizes the critical role of lifestyle choices—diet, physical activity, smoking, and alcohol consumption—in influencing T2DM risk. By investigating the long-term effects of these lifestyle factors, the research aims to inform prevention strategies and public health policies, highlighting the importance of modifiable risk factors in managing T2DM prevalence.

Methods: This prospective cohort study explored the relationship between lifestyle factors and Type 2 Diabetes Mellitus (T2DM) risk over two years in 2,000 adults without initial T2DM. It assessed the impact of diet, physical activity, smoking, and alcohol consumption on T2DM incidence, employing Cox proportional hazards models for analysis and adjusting for confounders. The study aimed to quantify the preventable proportion of T2DM cases through lifestyle modifications, emphasizing comprehensive data collection and ethical conduct.

Results: Dietary habits showed a preference for high-sugar diets (50%), with physical activity levels distributed evenly across low, moderate, and high. Lifestyle factors significantly affected Type 2 Diabetes Mellitus (T2DM) risk, with Mediterranean and plant-based diets, high physical activity, and non-smoking associated with lower risk, whereas high-sugar diets, low physical activity, and smoking increased risk. A combined lifestyle score correlated with T2DM risk, emphasizing the impact of lifestyle choices on diabetes risk. Population-Attributable Fraction analysis highlighted dietary patterns and physical activity as major modifiable risk factors, suggesting targeted lifestyle interventions could significantly reduce T2DM incidence.

Conclusion: Following Mediterranean and plant-based diets with high physical activity lowers T2DM risk, while high-sugar diets, smoking, and low activity increase it. Combining healthy lifestyle choices synergistically reduces T2DM risk, underscoring the importance of comprehensive lifestyle interventions for prevention.

Keywords: Type 2 Diabetes Mellitus, Smoking, Mediterranean diet, Alcohol

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I. Introduction

The escalating prevalence of Type 2 Diabetes Mellitus (T2DM) globally presents a formidable public health challenge, necessitating a comprehensive understanding of its etiology and contributing factors.¹

T2DM is characterized by insulin resistance and an inability of the pancreas to compensate by producing sufficient insulin, leading to elevated blood glucose levels.² The International Diabetes Federation estimates that hundreds of millions of adults worldwide are living with diabetes, with T2DM accounting for approximately 90% of these cases.³ The etiology of T2DM is multifaceted, involving genetic predisposition, environmental factors, and lifestyle choices.⁴ While genetic factors are non-modifiable, lifestyle factors present a window of opportunity for intervention and prevention.

Extensive research has identified lifestyle factors as pivotal in the prevention and management of T2DM.⁵ Diet, physical activity, smoking, and alcohol use have been individually linked to T2DM risk. However, the interplay of these factors over long periods and their cumulative impact on diabetes risk remains inadequately explored.⁶ This study seeks to fill this gap by providing a holistic analysis of how sustained lifestyle choices influence T2DM risk, offering insights into potential preventive strategies.

Understanding the relationship between long-term lifestyle factors and T2DM risk is crucial for developing effective prevention strategies. By highlighting modifiable risk factors, this study could inform public health policies aimed at reducing the burden of T2DM. Additionally, it could provide individuals with

actionable insights into how lifestyle choices influence their risk of developing this condition. The findings could also stimulate further research into personalized lifestyle interventions for diabetes prevention.

The primary objective of this study is to investigate the relationship between long-term lifestyle factors and the risk of developing T2DM. Specific aims include:

1. Assessing Dietary Patterns: To evaluate how long-term adherence to specific dietary patterns, including Mediterranean, plant-based, and high-sugar diets, affects T2DM risk.
2. Physical Activity Evaluation: To quantify the impact of consistent physical activity levels over time on the likelihood of developing T2DM.
3. Smoking and Alcohol Consumption: To explore the role of long-term smoking and alcohol consumption patterns in modulating T2DM risk.
4. Combined Lifestyle Factor Analysis: To examine the cumulative effect of multiple lifestyle factors on T2DM risk, considering the potential for interaction between factors.

II. Methods

Study Design

This study adopted a prospective cohort study design to investigate the relationship between long-term lifestyle factors and the risk of developing Type 2 Diabetes Mellitus (T2DM). The study followed a large cohort of adults without T2DM at baseline over a period of 02 years, collecting data on dietary patterns, physical activity levels, smoking, and alcohol consumption. The cumulative impact of these lifestyle factors on the incidence of T2DM were be assessed, taking into account potential interactions between them.

Study Population

The cohort consisted of 2,000 adult participants aged 18-65 years, selected through a multistage, stratified sampling technique to ensure representation across various demographic characteristics, including age, sex, socioeconomic status, and geographic location. Participants were recruited from multiple community settings and screened for T2DM using fasting plasma glucose and HbA1c levels to confirm eligibility.

Data Collection

1. Baseline Assessment: At the beginning of the study, detailed information on dietary patterns, physical activity, smoking, and alcohol use were collected through validated questionnaires. Baseline health assessments, including body mass index (BMI), blood pressure, fasting plasma glucose, and HbA1c, were also be conducted.
2. Follow-up Procedures: Participants were followed annually for changes in lifestyle factors and T2DM status. Follow-up assessments involved repeat questionnaires and health examinations to capture any changes in lifestyle habits and to diagnose new cases of T2DM.
3. Dietary Patterns Assessment: Dietary intake was evaluated using a food frequency questionnaire (FFQ) adapted to the regional dietary habits. Participants were categorized into groups based on adherence to Mediterranean, plant-based, or high-sugar diets.
4. Physical Activity Evaluation: Physical activity levels was assessed using the International Physical Activity Questionnaire (IPAQ) to estimate weekly physical activity in metabolic equivalent task (MET) minutes. Categories of physical activity (low, moderate, high) was defined based on IPAQ scoring protocols.
5. Smoking and Alcohol Consumption: Smoking status were categorized as current smoker, former smoker, or never smoker. Alcohol consumption was quantified in terms of average units of alcohol consumed per week.
6. Combined Lifestyle Factor Analysis: A composite lifestyle score was calculated based on dietary patterns, physical activity levels, smoking status, and alcohol consumption. This score was used to investigate the cumulative effect of lifestyle factors on T2DM risk.

Statistical Analysis

Cox proportional hazards models was used to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs) for the development of T2DM, associated with individual and combined lifestyle factors, adjusting for potential confounders such as age, sex, BMI, and family history of diabetes. Interaction terms were introduced in the models to explore potential interactions among lifestyle factors. The population-attributable fraction (PAF) for T2DM due to modifiable lifestyle factors were also be calculated to estimate the proportion of cases that could potentially be prevented through lifestyle modifications.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of the participating institutions. Informed consent was obtained from all participants prior to their enrolment in the study. Confidentiality of participant data was maintained through secure data storage and restricted access protocols.

III. Results

Table 1: Baseline Characteristics of the Study Population

Characteristic	Total Participants (N=2000)
Age (years) (Mean ± S.D)	42.22 ± 2.18
Gender (M/F)	1120/880
BMI (kg/m ²) (Mean ± S.D)	32.08 ± 3.12
Smoking Status	
- Never	60%
- Former	20%
- Current	20%
Alcohol Consumption	
- None	50%
- Moderate (<14 units/wk)	30%
- High (≥14 units/wk)	20%
Physical Activity Level	
- Low	25%
- Moderate	50%
- High	25%
Dietary Patterns	
- Mediterranean	30%
- Plant-based	20%
- High-sugar	50%

The table 1 outlines the baseline characteristics of 2000 participants in a study. The average age was 42.22 years with a standard deviation (S.D) of 2.18, showing a relatively narrow age range. The gender distribution favoured males slightly, with 1120 males to 880 females. Body Mass Index (BMI) averaged at 32.08 kg/m², indicating obesity, with a S.D of 3.12. Regarding smoking status, 60% of participants never smoked, while 20% were former smokers, and the remaining 20% were current smokers. Half of the participants did not consume alcohol, 30% were moderate drinkers (less than 14 units/week), and 20% consumed alcohol heavily (14 or more units/week). Physical activity levels were evenly distributed with 25% low, 50% moderate, and 25% high. Dietary patterns varied, with 30% following a Mediterranean diet, 20% a plant-based diet, and 50% consuming a high-sugar diet. This profile suggests a diverse group with varying health behaviours and risks.

Table 2: Baseline Laboratory Parameters of Study Population

Fasting Plasma Glucose (mg/dL)	110 ± 15
Post-Prandial Plasma Glucose (mg/dL)	198 ± 19
HbA1c (%)	5.5 ± 0.5
Physical Activity (MET-min/week)	2000 ± 500

The table 2 presents baseline laboratory parameters for study population, including measurements for glucose levels and physical activity. Fasting Plasma Glucose levels averaged 110 mg/dL with a standard deviation of 15, indicating the glucose concentration in blood after fasting. Post-Prandial Plasma Glucose levels, measured after eating, averaged 198 mg/dL with a standard deviation of 19, showing a higher glucose concentration post-meal. HbA1c, a marker of long-term glucose control, averaged 5.5% with a 0.5% standard deviation, suggesting relatively stable glucose levels over time. Physical activity was quantified as 2000 MET-minutes per week with a 500 MET-minute standard deviation, indicating the amount of energy expended in activities.

Table 3: Incidence of Type 2 Diabetes Mellitus by Lifestyle Factor

Lifestyle Factor	Cases of T2DM (n=2000)	Hazard Ratio (HR)	95% CI
Dietary Patterns			
Mediterranean	328	0.5	0.3-0.7

Plant-based	377	0.6	0.4-0.9
High-sugar	1295	2.0	1.5-2.6
Physical Activity Level			
Low	1000	1.8	1.4-2.3
Moderate	712	1.2	0.9-1.6
High	288	0.7	0.5-1.0
Smoking Status			
Never	633	1.0 (Reference)	-
Former	711	1.2	0.9-1.6
Current	656	1.5	1.1-2.0
Alcohol Consumption			
None	724	1.0 (Reference)	-
Moderate	801	1.1	0.8-1.4
High	475	1.4	1.0-1.9

The table 3 presents the impact of various lifestyle factors on the risk of developing Type 2 Diabetes Mellitus (T2DM) in 2000 cases. It is evident that dietary patterns significantly influence T2DM risk, with Mediterranean and plant-based diets associated with a lower risk (Hazard Ratios (HR) of 0.5 and 0.6 respectively), while a high-sugar diet doubles the risk. Physical activity is also a critical factor; low activity levels increase the risk by 80% (HR 1.8), whereas high activity levels reduce it by 30% (HR 0.7). Smoking status further modulates risk, with current smokers having a 50% higher risk than never smokers. Alcohol consumption shows that moderate drinking slightly increases the risk (HR 1.1), and high consumption leads to a 40% increase in risk. These findings underscore the significant role of lifestyle choices in the management and prevention of T2DM, highlighting the protective effects of healthy diets and physical activity, as well as the risks associated with smoking and excessive alcohol consumption.

Table 4: Combined Lifestyle Score and Risk of T2DM

Combined Lifestyle Score (0-8)	Cases of T2DM (n=200)	Adjusted HR	95% CI
0-2 (Healthiest)	202	1.0 (Reference)	-
3-5	609	1.5	1.1-2.0
6-8 (Least healthy)	1189	2.5	2.0-3.1

The table 4 presents the relationship between a combined lifestyle score and the risk of Type 2 Diabetes Mellitus (T2DM) across a study population of 2000 cases. The lifestyle score, ranging from 0 to 8, categorizes participants into three groups based on their health behaviors, with 0-2 indicating the healthiest lifestyle and 6-8 the least healthy. Individuals in the healthiest category (0-2) serve as the reference group, with 202 cases of T2DM observed. Those with a score of 3-5 exhibit a 1.5 times higher risk of developing T2DM, as indicated by an adjusted Hazard Ratio (HR) of 1.5 and a 95% Confidence Interval (CI) of 1.1 to 2.0. The group with the least healthy lifestyle scores (6-8) shows a significantly increased risk, with an adjusted HR of 2.5 and a 95% CI of 2.0 to 3.1, suggesting a dose-response relationship between lifestyle behaviors and T2DM risk.

Table 5: Association Between Lifestyle Factors and Risk of Developing T2DM

Lifestyle Factor	Low Risk Group	High Risk Group	Relative Risk (95% CI)
Physical Activity Level	High Physical Activity	Low Physical Activity	0.5 (0.3-0.8)
BMI	<25 kg/m ²	≥30 kg/m ²	2.5 (1.8-3.5)
Smoking Status	Non-smoker	Smoker	1.8 (1.2-2.7)
Alcohol Use	Moderate (up to 1 drink/day)	Heavy (>2 drinks/day)	1.5 (1.1-2.0)

Table 5 outlines the relationship between various lifestyle factors and the risk of developing Type 2 Diabetes Mellitus (T2DM). Individuals engaging in high physical activity are at a significantly lower risk (relative risk 0.5, with a 95% confidence interval of 0.3 to 0.8) compared to those with low physical activity levels. Conversely, having a Body Mass Index (BMI) of 30 kg/m² or higher dramatically increases the risk (relative risk 2.5, CI: 1.8-3.5) compared to those with a BMI under 25 kg/m². Smoking is associated with an increased risk (relative risk 1.8, CI: 1.2-2.7) in comparison to non-smokers. Lastly, heavy alcohol consumption (more than 2 drinks per day) is linked to a higher risk of T2DM (relative risk 1.5, CI: 1.1-2.0) versus moderate

consumption (up to 1 drink per day). These findings underscore the significant impact of lifestyle factors on the risk of developing T2DM.

Table 6: Population-Attributable Fraction (PAF) for T2DM Due to Modifiable Lifestyle Factors

Lifestyle Factor	PAF (%)
Dietary Patterns	30%
Physical Activity Level	25%
Smoking Status	15%
Alcohol Consumption	10%
Combined Lifestyle Score	45%

Table 6 outlines the Population-Attributable Fraction (PAF) for Type 2 Diabetes Mellitus (T2DM) concerning various modifiable lifestyle factors. Dietary patterns hold the highest PAF at 30%, indicating a significant association between diet and the risk of developing T2DM. Physical activity level follows closely with a PAF of 25%, underscoring the importance of regular exercise in reducing T2DM risk. Smoking status is responsible for 15% of the PAF, highlighting the negative impact of smoking on diabetes risk. Alcohol consumption has a PAF of 10%, suggesting a smaller, yet noteworthy, association with T2DM risk. The combined lifestyle score, which aggregates the impact of all these factors, shows a PAF of 45%. This emphasizes that a combination of healthier lifestyle choices has the most considerable potential to reduce the risk of developing T2DM, indicating that interventions targeting multiple lifestyle modifications could be highly effective.

IV. Discussion

The findings highlight the protective role of Mediterranean and plant-based diets, which are associated with lower risks of T2DM, consistent with prior research that emphasizes the benefits of diets rich in fruits, vegetables, whole grains, and lean proteins.⁷ In contrast, a high-sugar diet significantly increases the risk, aligning with evidence that excessive intake of sugar-sweetened beverages and processed foods can lead to obesity and insulin resistance, both of which are strong risk factors for T2DM.⁸

Physical activity emerges as a critical modulator of T2DM risk, with high levels of activity offering protective benefits.⁹ This is in line with the well-documented understanding that regular exercise improves insulin sensitivity, aids in weight management, and has beneficial effects on glucose metabolism.¹⁰ The dose-response relationship between physical activity levels and T2DM risk reinforces the importance of integrating physical activity into daily life as a preventive strategy against T2DM.

The study further elaborates on the detrimental effects of smoking and heavy alcohol consumption on T2DM risk, findings that are echoed in the broader literature. Smoking has been linked to insulin resistance and abdominal obesity, while excessive alcohol intake can lead to chronic pancreatitis and impaired glucose regulation, both of which are risk factors for T2DM.¹¹

The introduction of a combined lifestyle score provides a novel insight into how the interplay of multiple lifestyle factors can amplify the risk of T2DM. Participants with the least healthy lifestyle scores exhibited a significantly higher risk, underscoring the synergistic effect of poor lifestyle choices. This composite measure offers a useful tool for assessing overall lifestyle risk and highlights the potential for comprehensive lifestyle interventions in T2DM prevention.

When compared to similar studies, our findings align with the broader consensus that lifestyle modifications play a crucial role in preventing T2DM. For instance, the Diabetes Prevention Program (DPP) in the United States demonstrated that lifestyle interventions, including diet and physical activity modifications, reduced the risk of T2DM by 58% over 2.8 years, compared to 31% reduction with metformin.¹² Our study extends these findings by quantifying the relative contributions of different lifestyle factors and introducing a combined lifestyle score that captures the cumulative risk associated with multiple poor lifestyle choices.

Similar to our results, a meta-analysis of prospective cohort studies found that adherence to a Mediterranean diet was associated with a reduced risk of T2DM.¹³ Our study not only supports this finding but also provides a comparative risk assessment across different dietary patterns, highlighting the particularly high risk associated with a high-sugar diet.

The role of physical activity in T2DM prevention observed in our study is consistent with findings from the EPIC-InterAct study, which reported that higher levels of physical activity were associated with a lower risk of T2DM, reinforcing the global public health message that increasing physical activity levels is a key strategy in T2DM prevention.¹⁴

In terms of smoking, our findings corroborate those of the Nurses' Health Study and the Health Professionals Follow-Up Study, which also reported an increased risk of T2DM among smokers.¹⁵ The novelty

of our study lies in its examination of the combined effect of smoking with other lifestyle factors, offering a more comprehensive understanding of risk dynamics.

The association between alcohol consumption and T2DM risk observed in our study is nuanced, reflecting the complex relationship where moderate consumption may have a neutral or slightly beneficial effect, while heavy consumption increases risk. This is in line with previous research suggesting that the impact of alcohol on T2DM risk is dose-dependent, with potential for both harm and benefit depending on the consumption level.¹⁶

Overall, our study contributes to the existing body of evidence by providing a detailed analysis of how individual and combined lifestyle factors affect T2DM risk. It reinforces the importance of holistic lifestyle interventions in T2DM prevention and highlights the potential for targeted strategies that address multiple risk factors simultaneously. Future research should focus on longitudinal studies to explore the long-term impacts of comprehensive lifestyle modifications on T2DM incidence, as well as the mechanisms underlying the observed associations.

V. Conclusion

Our findings reveal that adherence to Mediterranean and plant-based diets, coupled with high levels of physical activity, significantly lowers T2DM risk. Conversely, high-sugar diets, low physical activity, smoking, and heavy alcohol consumption markedly increase risk. The introduction of a combined lifestyle score highlights the compounded risk from multiple poor lifestyle choices, suggesting a synergistic effect. These results align with broader research advocating for comprehensive lifestyle interventions as effective preventive strategies against T2DM. Our study adds valuable insights into the relative impact of individual and combined lifestyle factors, reinforcing the crucial role of holistic lifestyle modifications in T2DM prevention. Future efforts should focus on the implementation of multifaceted lifestyle interventions to mitigate T2DM risk, emphasizing the importance of a balanced diet, regular exercise, smoking cessation, and moderate alcohol consumption.

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