

# A retrospective study of 5S behaviours of Physical Activity (PA) among suburban Mumbai population with Type 2 Diabetes Mellitus (T2DM)

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## ABSTRACT

**Background:** T2DM is a chronic metabolic disorder to manage the same lifestyle modification is cornerstone. In 2022, the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) published a consensus report targeting the management of Type 2 Diabetes Mellitus (T2DM), which emphasised the importance of regular aerobic and resistance exercise. Both forms of physical activity (PA) can improve blood glucose, HbA1C levels, flexibility and balance. The ADA and EASD has categorised PA behaviours into 5 S. The 5 S stands for:- Sitting, Stepping, Sleep Sweating, Strengthening. The current study aims at auditing these 5S behaviours in suburban Mumbai population with its impact on HbA1C and body mass index (BMI). **Methodology:** A Retrospective, questionnaire-based study was conducted in the Endocrinology outpatient department of tertiary care institute in Mumbai suburban district. The demographic details, anthropometric measurements, HbA1C levels, sleep cycle and daily PA schedule including the 5S behaviours were recorded. The data generated was then statistically analysed using the IBM SPSS software v. 23. **Results:** The study included a total of 356 T2DM participants. Prolong sitting had a statistically significant correlation with BMI ( $P$  value = 0.003) and HbA1c levels ( $P$  value = 0.001), similarly strength training had a positive correlation with HbA1c ( $P$  value = 0.048) as well as with total sleep hours ( $P$  value < 0.0001). Behaviour like drowsiness was positively correlated with changing shift duty. Additionally, in the present study, it was also observed that more than half of the study population (55.8%) did not track their daily steps. **Conclusion:** The findings of the present study emphasize the importance of reducing sedentary time, promoting strength training and enhancing sleep quality in T2DM management. Targeted interventions in these areas can help improve health outcomes and quality of life for T2DM patients.

**Keywords:** 5S behaviour, obesity, physical activity, prolong sitting, T2DM

## Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by high levels of blood glucose (hyperglycaemia) either due

to inadequate insulin production, ineffective insulin action, or both. Untreated or poorly managed diabetes can lead to a range of complications affecting various organ systems, These complications include cardiovascular disease, neuropathy, nephropathy, retinopathy and foot problems, which in turn affect the overall well-being of the person.<sup>[1,2]</sup>

The prevalence of diabetes mellitus has been increasing globally over the past few decades. According to data for the year 2021

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from the International Diabetes Federation, approximately 537 million adults (aged 20–79 years) were diagnosed with diabetes worldwide, and if the trend continues this number is expected to rise to 784 million by 2045. The prevalence of diabetes varies by region, with the Western Pacific region having the highest number of cases, followed by Southeast Asia and Europe.<sup>[3]</sup> As per the Indian Council of Medical Research – India Diabetes study published in 2023, the prevalence of diabetes is 10.1 crores in India.<sup>[4]</sup>

Furthermore, Diabetes imposes a substantial economic burden on healthcare systems due to the costs associated with medical care, hospitalizations, medications and complications management. Diabetes has a profound influence on overall well-being, touching upon physical health, emotional equilibrium and social connections.

Lifestyle management is a fundamental aspect of diabetes care and it includes diabetes self-management and education support, daily monitoring of blood glucose level, medical nutrition therapy, regular physical activity (PA), smoking cessation counselling and psychosocial care.<sup>[5-7]</sup> Individuals diagnosed with Type 2 Diabetes Mellitus (T2DM), alongside healthcare providers (HCPs), collaborate to optimize lifestyle starting from the initial medical evaluation, through subsequent follow-ups, and the assessment of complications and management of other comorbid conditions, all aimed at improving diabetes care. HCPs play a pivotal role in motivating patients with diabetes to maintain a physically healthy lifestyle. This includes cultivating habits of regular sleep patterns by integrating step-counting using smartphones and smartwatches, being mindful of prolonged sitting, and incorporating simple resistance exercises using weights or bands. Embracing these changes in daily routines may aid in managing glycaemic spikes effectively.<sup>[5,6,8]</sup>

PA plays a vital role in everyone's life whether diabetic or not. However, if an individual who is diabetic or Pre-diabetic, PA should be on their to-do list. PA controls blood sugar levels and lowers the risk of heart disease and nerve damage.<sup>[8]</sup> In 2022, the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) published a consensus report targeting the management of type 2 diabetes. This consensus report is aimed at healthcare providers who play a crucial role in assisting individuals diagnosed with T2DM. According to the latest guidelines, there are five key health behaviours that people with diabetes should prioritize to effectively manage their condition. The five key health behaviour is defined as “5S” in which 5 S's stands for Sitting, Stepping, Sweating, Strengthening and Sleep. In addition to encouraging diabetes self-management education and focusing on glycaemic control, the report focuses on other factors that should be considered. One of these is “24-hour physical activity (PA) behaviours.” where individuals should not indulge much in sedentary activities. The ADA and EASD Consensus Report emphasizes the importance of regular aerobic exercise that involves large muscle groups and resistance exercise which

includes using own body weight or working against resistance. Both forms of PA can improve blood sugars, HbA1C levels, flexibility and balance.<sup>[9]</sup>

Mumbai, as the economic capital of India, boasts a densely populated environment with residents from diverse socio-economic backgrounds engaged in various fields of employment to meet their needs. However, urbanization and economic growth have resulted in increasingly erratic lifestyles, characterized by overwork, shift-based jobs, lengthy commutes, poor dietary habits and disrupted sleep schedules. These factors significantly contribute to lifestyle-related disorders. Despite the presence of robust healthcare facilities, the average life expectancy of Mumbaikars is relatively low, which is 56.8 years (52.6 years for men and 58.1 years for women). The prevalence of diabetes in Mumbai surpasses that of other metro cities in India, with approximately 18% of the population aged between 18 to 69 years being found to have impaired blood glucose levels.<sup>[10,11]</sup>

Therefore, the primary objective of the study was to assess the 5S behaviours [Table 1] related to PA in individuals with T2DM in Mumbai's suburban population. Additionally, the study aimed to identify factors influencing these behaviours and assess their impact on HbA1C levels and body mass index (BMI).

## Subjects and Methods

This was a Retrospective, questionnaire-based study conducted in the Endocrine Department of a tertiary care institute in the Mumbai suburban district. The collection of the data started after receiving Ethical Approval (BMRC/29/2023). The total duration of the study was 1 year. In total, 356 participants were included in the study with a margin of error – of 3.99%.

Participants of all genders, aged  $\geq 18$  years and who were diagnosed with T2DM, with an HbA1c level of above 6.5% were included in the study. Participants who were diagnosed with T1DM, Gestational Diabetes, malignancy, chronic kidney disease (eGFR  $< 30$ ), Ishaemic heart disease (IHD) (EF  $< 40\%$ ), COVID-19 infection, severe chronic obstructive airway disease and any other illness compromising the mobility of the person were excluded from the study.

After obtaining voluntary consent, participants received a counselling from a diabetes educator and dietician on the importance of the 5S characteristics. They were informed about the benefits of minimizing prolonged sitting, achieving a step count of over 5,000 steps per day, and ensuring 8 h of quality sleep to help improve HbA1C levels and enhance overall well-being. Following this counselling, data was collected on various parameters, including demographic details (such as age, background and education level), medical history (including conditions such as hypertension, hypothyroidism and past hospitalizations), HbA1C levels, BMI, and occupation details, including shift schedules, travel duration and mode of transport. A subsequent assessment involved a questionnaire divided

into subcategories addressing the 5S aspects: sitting habits, step count, sleep cycle (duration, quality, snoring habits, etc.), and exercise regimen (cardio/strength training). Additionally, questions regarding sweating conditions were included, depending on the workout regimen. The study’s questionnaire was thoroughly validated by experts and approved by the Ethics Committee (EC). Participants used their mobile phone’s built-in health applications (e.g. Apple Health, Samsung Health) and smartwatches to monitor and track their 5S behaviours.

The numeric data was summarized by descriptive statistics like; n, Mean ± SD, median, minimum and maximum. The categorical data was summarized by frequency count and percentage, and significance was analysed using the Chi-square. All statistical data was analysed by IBM SPSS software v. 23. A *P* value less than 0.05 was considered statistically significant.

### Results

The study comprised a total of 356 participants, with a mean age of 51.1 years consisting of 186 (52.8%) females and 170 (47.2%) males. The average BMI of the participants was 28.9 kg/m<sup>2</sup> with mean HbA1c levels of 8.5% [Table 2]. Findings revealed that 59% of participants engaged in prolonged sitting for more than 6 h. Moreover, 55.8% of the population failed to monitor their step count, with only 31.7% achieving a step count exceeding 6000 steps. Despite the importance of sleep, it was observed that 41% of participants slept for less than 7 h. Additionally, 39.2% of participants regularly engaged in moderate-intensity workouts, while 61% did not incorporate strength training into their routines [Table 3].

A statistically significant positive correlation was identified between shift duty and drowsiness (*P* value = 0.006\*). However, no statistical correlation was observed between prolonged sitting and snoring in relation to shift duty [Table 4].

A robust and statistically significant positive correlation was observed between snoring and BMI, HbA1c and Sleep Hours (*P* values <0.0001, 0.071, <0.0001, respectively). Participants who reported a habit of snoring exhibited mean values of 30.3 for BMI, 8.44 for HbA1c and 7.01 for Sleep Hours [Table 5].

Step counts and prolonged sitting were both positively correlated with HbA1c levels (*P* values = 0.002, 0.006), indicating their influence on glycaemic control. However, no statistically significant positive correlation was found between sleep hours, sweating, or strength training and HbA1c levels [Table 6].

### Discussion

A sedentary lifestyle is a major limiting factor for good T2DM outcomes yet it has become normal in urban areas. A sedentary lifestyle is found to be associated with more prevalence of T2DM and reduced life expectancy. This year the ADA-EASD defined 5 sedentary behaviours. The present study focuses on the analysis of these behaviours in the suburban Mumbai population and their effect on BMI and HbA1C.<sup>[9]</sup>

Cross-sectional studies have shown that daily step counts are inversely related to BMI, hypertension and diabetes.<sup>[12]</sup> However, in the present study, it was observed that most of the participants (55.8%) were not calculating their steps, and 31.7% of participants had their step count of more than 6000 steps per day [Table 3]. According to the results of the observational study conducted in Delhi, it was observed that Short duration of sleep was significantly associated with higher HbA1c levels. Good sleep quality significantly reduced the fasting plasma glucose levels,<sup>[13]</sup> however, in our study a higher number of participants (41.8%) had a sleep duration of less than 7 h [Table 3]. According to the study conducted in Iran, it was observed that the participants spent an average

**Table 1: 5S Parameters as per ADA and EASD Consensus 2022<sup>[9]</sup>**

Attributes	Recommendation	Hazards	Remarks
Prolong Sitting	Limit Prolong sitting	Life threatening as smoking	Take a 2 mins break after every 30 – 45 min of sitting where you can walk around or stretch
Stepping	7000 —8000 steps/day	Increases the risks of CVDs, Obesity and T2DM	Set a target and Count your steps with your smartphones or watches, be conscious to achieve the target.
Sleep	7 to 8 hours of Sleep/day	Irregular sleep results in poor glycaemic control which further influence by OSA, Insomnia, restless leg syndrome.	Maintain a regular sleep cycle, follow a sleep routine. Try to finish dinner early if possible
Strength Training	Moderate to high intensity muscle strengthening exercise at least twice a week	Lack of strength training can cause muscle loss, increases risk of fall, decline in cognitive functions of the body in elders.	Exercises that involves activities in which the person’s using their own weight or works against the force is known as Resistance Exercise, such kind of exercise will help in improving the insulin sensitivity and glucose levels
Sweating	Sweating is body’s response to energy expenditure. Moderate (>150 mins/week) to Vigorous (>75 mins/week) intensity physical activity improves the metabolic profiles.	The phenotype of T2DM is unique, generally encircling overweight and Obesity. Thus for them the ability to perform functional exercises for middle age individuals is similar to those over a decade older.	Indulge in moderate intensity workouts involving both cardio and muscle muscles building exercise for improving the glycaemic control

**Table 2: Baseline characteristics of the population**

Characteristics	Mean	Standard Deviation
Weight (kg)	76.675	17.130
Height (cm)	161.011	12.854
BMI (kg/m <sup>2</sup> )	28.981	5.242
HbA1c (%)	8.5	1.735

**Table 3: Frequency table based on 5S behaviour of the population**

Data Parameters (5S Behaviour)	Variables	n	%
Step Count	<6000 steps	113	31.7
	>6000 steps	105	29.4
	No calculating the step count	199	55.8%
Sleep	<7 hours	101	28.3%
	7 hours	105	29.4%
	>7 hours	149	41.8%
Prolong Sitting	<6 hours	212	59.5%
	>6 hours	144	40.4%
Strength Training	Yes	136	39.2%
	No	220	61.7%
Sweating	Yes	130	36.5%
	No	226	63.4%

**Table 4: Association of shift duty with prolong sitting, snoring and drowsiness**

Association with shift duty	Variables	Shift Duty			P
		Day	Night	Rotational	
Prolong sitting	Yes	82 (54.6%)	115 (62.8%)	15 (65.2%)	0.27
	No	68 (45.3%)	68 (37.1%)	8 (34.7%)	
	Total	150 (100%)	183 (100%)	23 (100%)	
Snoring	Yes	87 (58%)	113 (61.7%)	10 (43.4%)	0.23
	No	113 (75.3%)	70 (38.2%)	13 (56.5%)	
	Total	150 (100%)	183 (100%)	23 (100%)	
Drowsiness	Yes	70 (46.6%)	96 (37.7%)	19 (82.6%)	0.006*
	No	80 (53.3%)	87 (47.5%)	4 (17.3%)	
	Total	150 (100%)	183 (100%)	23 (100%)	

**Table 5: Comparison of parameters with BMI, HbA1C levels and Sleep**

Comparison	Variables	Mean±SD		
		BMI	HbA1c	Sleep Hours
Snoring	Yes (n=210)	30.30±5.275	8.44±1.591	7.01±1.091
	No (n=146)	27.35±4.611	8.78±1.952	6.53±0.919
	P	<0.0001	0.071	<0.0001
Strength Training	Yes (n=136)	29.71±5.282	8.81±1.629	6.33±0.844
	No (n=220)	28.71±5.145	8.44±1.815	7.12±1.053
	P	0.08	0.048*	<0.0001*
Sweating	Yes (n=130)	29.72±4.983	8.81±1.929	6.77±1.038
	No (n=226)	28.73±5.318	8.45±1.634	6.85±1.057
	P	0.085	0.06	0.51
Prolong Sitting	Yes (n=212)	29.78±5.481	8.84±1.757	6.81±1.076
	No (n=144)	28.08±1.757	8.20±1.683	6.83±1.013
	P	0.003*	0.001*	0.89

of 6.29 h of an 8-h working shift in a sitting position, further the study indicated that long sitting times were associated with hypertension, diabetes and musculoskeletal disorder symptoms,<sup>[14]</sup> similarly in the present study almost 59.5% of participants had a prolonged sitting habits of more than 6 h [Table 3]. Also, in the present study, it was particularly observed that participants who had rotational shift duty (62.8%) had a prolong sitting habits when compared with those who had day shift duty (54.6%), however, no statistically significant correlation was found between prolong sitting and shift duty [Table 4]. A study conducted in Korean patients with diabetes found that regular physical exercise was associated with controlled HbA1c levels. Particularly, practicing resistance exercise may contribute more to the management of their HbA1c levels than walking exercise. Promoting resistance exercise performance can be beneficial for improving the condition of patients with diabetes.<sup>[15]</sup> However, in our study, 61.7% of participants did not engage in PAs [Table 3]. There is evidence that shift-based work can affect sleep mechanisms like various biopsychosocial pathways which can lead to various health outcomes,<sup>[16]</sup> similarly in our study it was observed that 61.7% of participants who were doing night shifts had a habit of snoring [Table 4]. A study conducted in Korea to evaluate the relationship between metabolic syndrome in women and snoring revealed that BMI was significantly higher in the group with snoring than in the group without snoring ( $P < 0.001$ ),<sup>[17]</sup> the results of this study is similar lines with the current study in which a positive correlation was observed between BMI and snoring habits of the participants ( $P < 0.0001$ ) [Table 5].

The meta-analysis highlighted the significant reduction of HbA1c through resistance training.<sup>[18]</sup> In alignment with these findings, a study conducted in Jordan aimed to assess the impact of resistance training on HbA1c levels among type 2 diabetes patients. The group undergoing resistance exercises exhibited noteworthy differences in daily plasma glucose readings ( $P < 0.001$ ). Notably, the resistance exercise cohort exhibited a more pronounced reduction, with their HbA1c levels significantly lower than those of the treadmill exercise group at the 10-week mark ( $P < 0.006$ ).<sup>[19]</sup> These findings are consistent with our current study, wherein a positive correlation between strength training and HbA1c levels was observed ( $P$  value = 0.048\*) [Table 5].

Prolonged Sitting is considered equivalent to smoking. Prolonged sitting has been associated with insulin resistance and higher risks for various health-related problems such as cardiovascular disease, T2DM and obesity. An average individual spends six to eight hours a day sitting.<sup>[20,21]</sup> In the present study, a statistically significant correlation was found between prolonged sitting with BMI ( $P$  value = 0.003\*) and HbA1c ( $P$  value = 0.001\*) [Table 5], this observation is similar to the study conducted in the USA, where they correlated prolonged sitting with BMI in participants with Sedentary work ( $P$  value = <0.05).<sup>[20]</sup> It is important that prolonged sitting be interrupted by light walking or simple resistance activities to improve glycaemic control as seen in the study increase in moderate vigorous PA was associated

**Table 6: Prediction for BMI and HbA1c with 5S Parameters**

Variables	Beta	t	P	95% CI	
Prediction of BMI on 5S parameter					
Step count	-0.140	-2.503	0.013	0.000	0.000
Sleep hours	-0.111	-1.994	0.047	-1.092	-0.008
Sweating	-0.100	-1.912	0.057	-2.191	0.031
Strength training	-0.077	-1.308	0.192	-2.058	0.414
Prolong sitting	-0.131	-2.493	0.013	-2.494	-0.294
Prediction of HbA1c on 5S parameter					
Step count	-0.171	-3.078	0.002	0.000	0.000
Sleep hours	-0.052	-0.946	0.345	-0.269	0.094
Sweating	-0.111	-2.139	0.033	-0.776	-0.032
Strength training	-0.118	-2.015	0.045	-0.837	-0.010
Prolong sitting	-0.144	-2.746	0.006	-0.882	-0.146

with a reduction in HbA1c level in those individuals with dysglycemia ( $P$  value = 0.001).<sup>[21-25]</sup>

Sleep is another important aspect in living a healthy life. Reduction in sleep hours and sleep quality have been associated with worse glycaemic control. Sleep deprivation leads to alter the circadian cycle thereby leading to metabolic and hormonal disorders.<sup>[26-28]</sup> In previous studies, it has been observed that metabolic syndrome is more common in rotational shift workers.<sup>[29-31]</sup> The results of previous study is in similar lines to the current study in which it was noted that poor glycaemic control was observed in participants with rotational shifts as compared with participants with fixed day or night shifts (but no difference in BMI and step counts in the groups).<sup>[29]</sup> The present study is unique in pointing out this observation that fixed-hour work shifts (day or night) had a good glucose control however participants with rotational shifts does not have a good control implying the inability of circadian hormones to adapt at shorter intervals.<sup>[30]</sup> Our study found a significant association between increased sleep hours and BMI (negatively correlated) [Table 6].

Stepping is one of the important aspects of PA and it is encouraged that people with T2DM mindfully take 8000–10000 steps per day.<sup>[32,33]</sup> Stepping confers metabolic benefits and cardiovascular protection in T2DM and also devices for monitoring step counts can be a useful cardiovascular marker and hold potential in community oriented settings as an intervention tool<sup>[32,33]</sup> For each 1000 daily step count increase at baseline, there is a reduction in all-cause mortality by 36% and CVDs by 21% and promoting insulin sensitivity by 15%.<sup>[32]</sup> Individuals should count their steps using the step counting apps and try to increase at least 500 steps each day for better health.<sup>[33-35]</sup> The present study highlights that a good number of homemakers (63.3%) are not mindful of the steps they take and there is felt need of sensitisation for same. Those who are employed took more steps than those who were retired/unemployed implying that stepping as a part of work also adds on to PA. It is also possible that the retired/unemployed represent a physically less capable population and so could have fewer step counts. In our study, higher step count was correlated with lower HbA1C and BMI.

Strength training, a kind of workout routine where muscles are targeted. Inactive adults experience a 3% to 8% loss of muscle mass per decade which can be reduced by strength Training.<sup>[36]</sup> It has been shown to improve physical performance, cognitive abilities, functional independence and self-esteem thereby improving insulin sensitivity and can assist in the prevention and management of T2DM by decreasing visceral fat, reducing the HbA1C, increasing the density of GLUT 4 receptors.<sup>[5,37,38]</sup> For people living with T2DM, PA is the best way to manage the blood glucose level and sweating here implies PA is intense enough to cause Sweating.<sup>[36,39]</sup> Our study shows that strength training does improve glycaemic control and also sleep hours. Individuals with this degree of PA should have better glycaemic control but our study did not find this though the benefit for HbA1C reduction tended to be significance with  $P = 0.06$ . However, in regression analysis sweating did correlate with a reduction in HbA1C [Table 6].

### Limitations

As the study was questionnaire based study, detailed PA behaviour was not reported. The study could have been better if proper devices had been used to monitor their step count, sleep quality and sitting habits. The study did not take diet and other lifestyle parameters such as stress into consideration.

### Conclusion

The current study provides valuable insights into the lifestyle behaviours of individuals with Type 2 Diabetes Mellitus in suburban Mumbai, focusing on the 5S framework proposed by the ADA and the EASD. Prolonged sitting was found to have a statistically significant correlation with both BMI and HbA1c levels, indicating its detrimental impact on weight management and blood glucose control. Conversely, engagement in strength training showed a positive correlation with better HbA1c levels and improved sleep duration, underscoring the benefits of incorporating resistance exercise into daily routines. Overall, the study signifies the importance of the 5S behaviours in the management of T2DM and calls for targeted interventions to reduce sedentary time, promote strength training and improve sleep quality among patients. By addressing these key areas, healthcare providers can help individuals with T2DM achieve better health outcomes and enhance their quality of life.

### List of Abbreviations:

Abbreviation	Definition
IDF	International Diabetes Federation
ICMR INDIAB	Indian Council of Medical Research – India Diabetes
DSMES	Diabetes self – management and education support
MNT	Medical Nutrition Therapy
HCPs	Healthcare Providers
ADA	American Diabetes Association
EASD	European Association for the Study of Diabetes
5S	Sitting, Stepping, Sweating, Strengthening and Sleep

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Ms Vrutti Mistry (Clinical Research Associate)	For assisting in manuscript writeup and data analysis
Ms Vedanti Patil (Data Entry Operator)	For assisting in publication process of the manuscript

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## Conflicts of interest

There are no conflicts of interest.

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