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\* **Corresponding author.**

[communitynutritionforum@gmail.com](mailto:communitynutritionforum@gmail.com)

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## Prevalence of Diabetes Risk in Kerala Using the Indian Diabetes Risk Score (IDRS): Insights for Public Health Action

Sherin Thomas<sup>1</sup>, N Fida Jabir<sup>2</sup>, Fiza Nawaz<sup>3</sup>, Jothi James<sup>4</sup>, Leena Saju<sup>5</sup>, V Sruthi Mol<sup>6</sup>, Sripriya Shaji<sup>7\*</sup>

**1** Senior Manager, Department of Clinical Nutrition, Aster Mims, Calicut / President, Community Nutrition Forum, Kerala, India.

**2** Chief Dietitian & Research Associate, Clinical Nutrition Department, Iqraa International Hospital and Research Centre, Malaparamba, Kozhikode / Member, Community Nutrition Forum, Kerala, India.

**3** Project Associate, DST SEED project, St. Teresa's College, Ernakulam / Member, Community Nutrition Forum, Kerala, India.

**4** Dietician cum Counselor, Government Taluk Hospital Feroke, Kozhikode / Treasurer, Community Nutrition Forum, Kerala, India.

**5** Group Manager- Clinical Nutrition, KIMS Health, Trivandrum / Member, Community Nutrition Forum, Kerala, India.

**6** Dietitian and Administrative officer, Institute of Applied Dermatology, Kasaragod / Member, Community Nutrition Forum, Kerala, India.

**7** Counselling Psychologist and Nutritionist, Srisha Counselling, Kozhikode / Secretary, Community Nutrition Forum, Kerala, India.

### Abstract

Diabetes mellitus (DM) is a growing global health concern, with lifestyle changes and inactivity fueling its rise. A community-based cross-sectional study in Kerala, India (Nov–Dec 2023), assessed diabetes risk among 714 adults (18–90 years) across 14 districts using the Indian Diabetes Risk Score (IDRS). Findings showed 65.2% at moderate risk and 26.8% at high risk, with variations by age, gender, BMI, comorbidities, and region. Women had a higher high-risk proportion than men (28.6% vs. 21.4%). Obesity was a key determinant, as 39.3% with Obesity Class II were at high risk. Regional analysis revealed South Kerala as the most affected (36.5% high risk). Participants with comorbidities showed significantly greater vulnerability. These results highlight the urgent need for robust public health strategies focusing on diabetes education, early screening, and targeted interventions. Bridging the gap between awareness and action is critical to mitigating Kerala's diabetes burden and its socio-economic consequences.

**Keywords:** Diabetes mellitus, Indian Diabetes Risk Score (IDRS), Obesity, Comorbidities, Kerala, Community-based study, Public health

### 1 Introduction

Diabetes mellitus is a rapidly escalating global health issue, and India stands at the forefront of this epidemic, often termed the “diabetes capital” of the world. Kerala, a state known for its advanced health indicators compared to other Indian states, paradoxically faces one of the highest rates of diabetes in the country. Despite Kerala's overall improved life expectancy, literacy rates, and healthcare access, it has also witnessed significant lifestyle changes over the past few decades. Urbanization, sedentary lifestyles, altered dietary patterns, and an aging population are driving a surge in non-communicable diseases (NCDs), including diabetes.

The prevalence of diabetes in Kerala is notably higher than the national average, with approximately one in five adults being affected, according to various studies. This sharp rise not only impacts the quality of life of individuals but also imposes a heavy burden on the healthcare system. As diabetes remains a lifelong condition with significant complications such as cardiovascular disease, neuropathy, nephropathy, and retinopathy, the costs associated with its management are substantial.

The Indian Diabetes Risk Score (IDRS) was developed specifically to address the unique characteristics of the Indian

population, which may be at risk of diabetes even with lower body mass index (BMI) compared to Western populations. IDRS is a simple, cost-effective tool that can be used for large-scale screening in community settings. It takes into account key risk factors like age, physical inactivity, abdominal obesity, and family history of diabetes, making it a valuable tool for identifying individuals at risk, especially in resource-limited environments.

### 1.1 The Need for the Study

Despite the alarming rise in diabetes cases in Kerala, there has been a relative lack of large-scale community-based screening studies to assess diabetes risk at the population level. Most existing studies focus on clinically diagnosed diabetes rather than the underlying risk in the general population. Given that a substantial portion of those at risk for diabetes may remain undiagnosed until they develop complications, early identification through risk assessment tools like the IDRS is critical for effective prevention.

This study is therefore crucial for several reasons:

- 1. Preventive Action:** Early identification of individuals at high risk for diabetes allows for timely interventions. These can include lifestyle modifications such as increased physical activity, dietary changes, and regular monitoring, potentially preventing or delaying the onset of diabetes.
- 2. Public Health Strategy:** Kerala’s health infrastructure is well-positioned to implement large-scale preventive measures. However, the lack of region-specific data on diabetes risk undermines the development of targeted public health policies. The study will provide empirical evidence that can guide the formulation of effective diabetes prevention strategies at the state level.
- 3. Burden on Healthcare:** Without proactive screening and intervention, the diabetes epidemic will continue to overwhelm Kerala’s healthcare system, leading to increased costs due to diabetes-related complications. This study will help prioritize resources for high-risk groups, ensuring more efficient use of public health funds.
- 4. Population-Specific Insights:** Kerala has unique socio-demographic characteristics, including a rapidly aging population and high levels of literacy. These factors could influence the prevalence of diabetes and the effectiveness of preventive measures. This study will provide insights specific to Kerala’s population, contributing to a deeper understanding of the drivers behind the state’s high diabetes rates.

By assessing the diabetes risk using the IDRS, this study aims to fill a critical gap in public health research in Kerala. The

findings will be invaluable in shaping public health policy, guiding early intervention programs, and potentially curbing the diabetes epidemic in the state before it reaches unmanageable proportions.

## 2 Methodology

### 2.1 Study Settings and design

This was a community based cross sectional study conducted from November 1, 2023 until December 31, 2023. The study was done among 2241 individuals in the age group 18 to 90 years in 14 districts of Kerala.

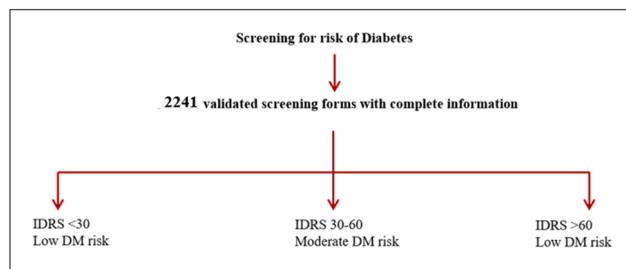


Fig. 1: Research design

### 2.2 Risk assessment tool IDRS score

Table 1: The Indian Diabetic Risk Score

Sl. No.	Factor	Score
<b>Age</b>		
1.	<35 years	0
	35-49 years	20
	>50 years	30
<b>Abdominal obesity</b>		
2.	<80 cm (F), <90 cm (M)	0
	80- 89 cm (F), 90-99 cm (M)	10
	>90 cm (F), >100 cm (M)	20
<b>Physical activity</b>		
3.	Vigorous exercise or Strenuous at work	0
	Moderate exercise at work / home	10
	Mild exercise at work / home	20
	No exercise at work / home	30
<b>Family history of diabetes</b>		
4.	No parent diabetic	0
	Either parent diabetic	10
	Both parents diabetic	20
	Maximum score	100
Scoring- <30: Low risk, 30-59: Moderate risk, ≥60: High risk		

(Reference: Mohan *et al.*, 2005<sup>(5)</sup>)

The study assessed diabetes risk as per the IDRS (Indian Diabetic Risk Score) and analysed the future risk of diabetes in the participants. The IDRS was developed by Mohan *et al.*<sup>(5)</sup> as

part of the Chennai Urban Rural Epidemiology Study (CURES) to assess the future risk of developing diabetes. It is a simplified risk score for identifying undiagnosed diabetic subjects taking into account two modifiable risk factors (waist circumference and physical inactivity) and two non-modifiable risk factors (age and family history of diabetes), which may be amenable to intervention. The individuals were classified as having high risk (score >60), moderate risk (score 30 - 50) and low risk score<sup>(2)</sup>.

Various studies have validated it, and its cost-effectiveness in screening prediabetics and diabetics is well documented<sup>(13)</sup>. The IDRS tool and its scoring is presented in (Table. 1).

### 2.3 Data collection

Data was collected in a questionnaire-based screening form. Demographic details of the participants such as name, gender, weight, height, educational qualification, area of residence, economical status, comorbidities were collected on a preformed questionnaire along the IDRS parameters- age, waist circumference, physical activity, and family history of diabetes. The economic status was measured using the Kuppusamy scale<sup>(6)</sup>.

### 2.4 Statistical analysis

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses.

**Descriptive Statistics-** Descriptive analysis of all the explanatory and outcome parameters will be done using frequency and proportions for categorical variables, whereas in Mean & SD for continuous variables.

**Inferential Statistics-** Kruskal Wallis Test followed by Dunn's post hoc test was used to compare the mean age based on the Risk of diabetes among study participants. Chi Square Test was used to compare the Risk of Diabetes as per IDRS based on the gender, education qualification, area of location, BMI status and comorbidity status of the study participants. The level of significance was set at  $p < 0.05$ .

## 3 Results

The study included a total of 2,241 participants, with the age distribution showing that 51.3% (n=1,150) were younger than 35 years, 31.9% (n=714) were between 35 and 49 years, and 16.8% (n=377) were 50 years or older. The mean age of the participants was  $36.52 \pm 12.19$  years, with ages ranging from 16 to 89 years. In terms of gender distribution, the majority of the participants were female, accounting for 74.4% (n=1,667) of the study population, while males made up the remaining 25.6% (n=574). These findings provided a comprehensive overview of the age and gender distribution among the study participants.

**Table 2: Age and Gender distribution among study participants**

Variable	Category	n	%
Age	< 35 yrs.	1150	51.3%
	35 - 49 yrs.	714	31.9%
	≥ 50 yrs.	377	16.8%
Gender	Males	574	25.6%
	Females	1667	74.4%

The distribution of educational qualifications among the study participants revealed that a majority, 56.0% (n=1,255), had an intermediate or diploma level of education. Graduates accounted for 9.0% (n=201) of the study population, while those with a high school certificate represented a very small proportion, at 0.1% (n=2). Additionally, a significant portion of the participants, 34.9% (n=783), were illiterate. These findings highlighted a varied range of educational backgrounds among the study participants, with the largest group having attained an intermediate or diploma level of education and a notable percentage being illiterate.

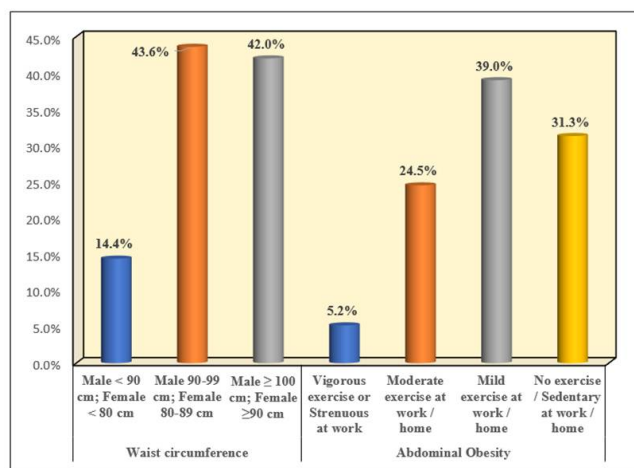
**Table 3: Distribution of Educational Qualification among study participants**

Variable	Category	n	%
Educational qualification	Graduate	201	9.0%
	Intermediate or diploma	1255	56.0%
	High School Certificate	2	0.1%
	Illiterate	783	34.9%

The distribution of anthropometric parameters among the study participants revealed several key patterns. In terms of waist circumference, 14.4% (n=322) of the participants had measurements less than 90 cm for males and less than 80 cm for females. The largest group, representing 43.6% (n=977) of the participants, had waist circumferences ranging from 90-99 cm for males and 80-89 cm for females. Additionally, 42.0% (n=942) of the participants had waist circumferences of 100 cm or more for males and 90 cm or more for females. Regarding abdominal obesity, the study found that only a small portion of the participants, 5.2% (n=117), engaged in vigorous exercise or had strenuous work activities. A larger group, accounting for 24.5% (n=549) of the participants, performed moderate exercise either at work or at home. The majority of the participants, 39.0% (n=873), engaged in mild exercise at work or home. Finally, 31.3% (n=702) of the participants reported no exercise or led a sedentary lifestyle at work or home. These findings highlighted the varying levels of waist circumference and physical activity among the study participants, with a significant portion exhibiting higher abdominal obesity and lower levels of physical activity.

**Table 4: Distribution of Anthropometric parameters among study participants**

Variable	Category	n	%
<b>Waist circumference</b>	Male < 90 cm; Female < 80 cm	322	14.4%
	Male 90-99 cm; Female 80-89 cm	977	43.6%
	Male ≥ 100 cm; Female ≥ 90 cm	942	42.0%
<b>Abdominal Obesity</b>	Vigorous exercise or Strenuous at work	117	5.2%
	Moderate exercise at work / home	549	24.5%
	Mild exercise at work / home	873	39.0%
	No exercise / Sedentary at work / home	702	31.3%



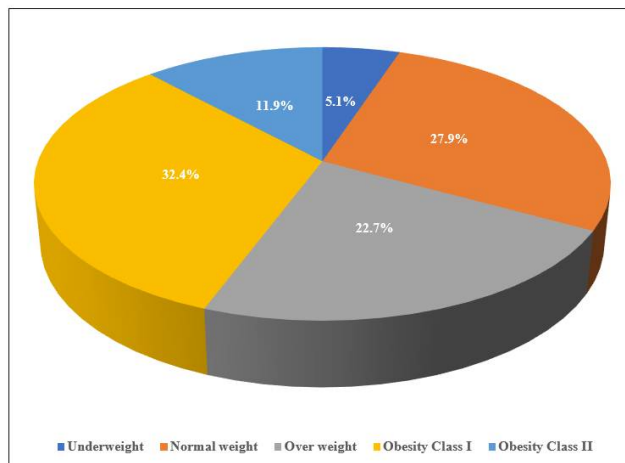
**Fig. 2: Distribution of Anthropometric parameters among study participants**

The distribution of BMI status among the study participants showed that a minority of the participants, 5.1% (n=114), were underweight. A larger group, representing 27.9% (n=626) of the participants, fell into the normal weight category. Additionally, 22.7% (n=508) of the participants were classified as overweight. A substantial proportion of the study population was categorized as Obesity Class I, accounting for 32.4% (n=726) of the participants. Furthermore, 11.9% (n=267) of the participants were classified as Obesity Class II. These findings indicated a diverse range of BMI statuses among the study participants, with a notable percentage falling into the obesity categories.

**Table 5: Distribution of BMI Status among study participants**

Variable	Category	n	%
<b>BMI Status</b>	Underweight	114	5.1%
	Normal weight	626	27.9%
	Over weight	508	22.7%
	Obesity Class I	726	32.4%
	Obesity Class II	267	11.9%

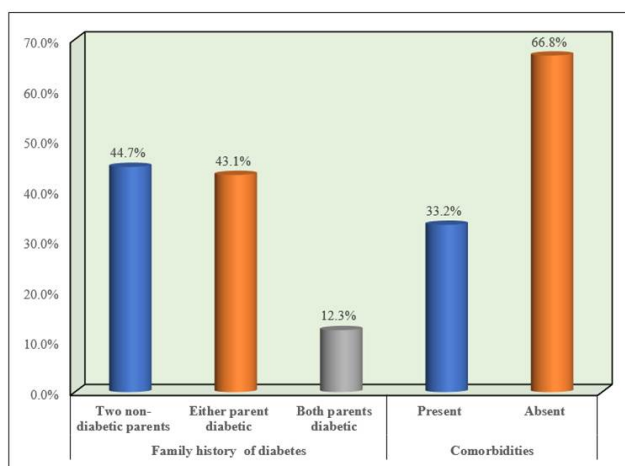
**Note:** The BMI Status have been classified based on Asian Pacific classification of BMI (Asia Pacific report WHO, IASO, IOTF 2000)<sup>(15)</sup>



**Fig. 3: Distribution of BMI Status among study participants**

**Table 6: Distribution of Family history of diabetes & Comorbidities among study participants**

Variable	Category	n	%
<b>Family history of diabetes</b>	Two non-diabetic parents	1001	44.7%
	Either parent diabetic	965	43.1%
	Both parents diabetic	275	12.3%
<b>Comorbidities</b>	Present	745	33.2%
	Absent	1496	66.8%



**Fig. 4: Distribution of Family history of diabetes & Comorbidities among study participants**

The distribution of family history of diabetes among the study participants showed that 44.7% (n=1,001) had two non-

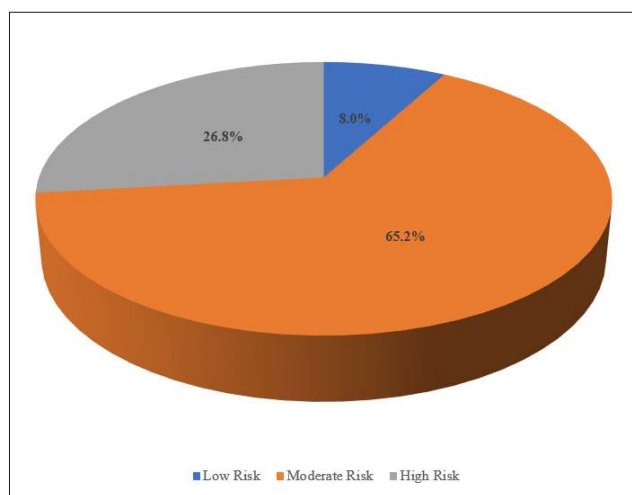
diabetic parents. A slightly lower percentage, 43.1% (n=965), had either parent diabetic, while 12.3% (n=275) had both parents diabetes.

In terms of comorbidities, 33.2% (n=745) of the participants had comorbid conditions, whereas 66.8% (n=1,496) did not have any comorbidities. These findings highlighted that a significant portion of the study participants had a family history of diabetes and that a notable percentage also had comorbid conditions.

The distribution of diabetes risk among the study participants, as assessed by the Indian Diabetes Risk Score (IDRS), indicated that a small portion, 8.0% (n=180), were classified as having a low risk of developing diabetes. The majority of the participants, 65.2% (n=1,461), were categorized as having a moderate risk. Additionally, 26.8% (n=600) of the participants were found to be at high risk of developing diabetes. These findings highlighted that a significant proportion of the study population fell into the moderate and high-risk categories, suggesting a substantial potential burden of diabetes among the participants.

**Table 7: Distribution of Diabetes Risk as per IDRS among study participants**

Variable	Category	n	%
Risk	Low Risk	180	8.0%
	Moderate Risk	1461	65.2%
	High Risk	600	26.8%



**Fig. 5: Distribution of Diabetes Risk as per IDRS among study participants**

**Table 8: Comparison of mean age based on the Risk of diabetes among study participants using Kruskal Wallis Test followed by Dunn's post hoc Test**

IDRS score	N	Mean	SD	Min	Max	p-value <sup>a</sup>	Sig. Diff	p-value <sup>b</sup>
Low Risk	180	28.47	7.81	16	54		L vs M	<0.001*
Moderate Risk	1461	34.90	11.55	17	89	<0.001*	L vs H	<0.001*
High Risk	600	42.88	12.06	18	84		M vs H	<0.001*

**Note:** a. Kruskal Wallis Test & b. Dunn's post hoc Test.

\* - Statistically Significant

For the Low Risk group, the mean age was 28.47 ± 7.81 years, with a minimum age of 16 and a maximum age of 54. For the Moderate Risk group, the mean age was 34.90 ± 11.55 years, with ages ranging from 17 to 89. The High Risk group had a mean age of 42.88 ± 12.06 years, with a minimum age of 18 and a maximum age of 84. The Test indicated a statistically significant difference in mean ages among the different risk groups (p < 0.001). Multiple comparison Test further revealed significant differences in mean ages between all pairs of risk groups (Low vs Moderate: p < 0.001; Low vs High: p < 0.001; Moderate vs High: p < 0.001). These results indicated that the mean age of participants increased with the risk of diabetes, with older ages associated with higher risk categories.

**Table 9: Comparison of Risk of Diabetes as per IDRS based on the gender of the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
Gender	Males	83	14.5%	368	64.1%	123	21.4%	<0.001*
	Females	97	5.8%	1093	65.6%	477	28.6%	

\* - Statistically Significant

The study compared the risk of diabetes based on the Indian Diabetes Risk Score (IDRS) across genders using the Chi-Square Test. Among male participants, 14.5% were classified as Low Risk, 64.1% as Moderate Risk, and 21.4% as High Risk. In contrast, among female participants, 5.8% were classified as Low Risk, 65.6% as Moderate Risk, and 28.6% as High Risk. The test revealed a statistically significant difference in the distribution of diabetes risk between males and females (p < 0.001). These findings highlighted that a higher proportion of females were at high risk of developing diabetes compared to males, despite both genders having a similar proportion in the moderate-risk category. This indicated a notable gender difference in diabetes risk, with females being more susceptible to higher risk levels.

**Table 10: Comparison of Risk of Diabetes as per IDRS based on the BMI Status of the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
BMI Status	Underweight	13	11.4%	89	78.1%	12	10.5%	<0.001*
	Normal weight	83	13.3%	413	66.0%	130	20.8%	
	Over weight	29	5.7%	332	65.4%	147	28.9%	
	Obesity Class I	46	6.3%	474	65.3%	206	28.4%	
	Obesity Class II	9	3.4%	153	57.3%	105	39.3%	

\* - Statistically Significant

The study highlighted significant variations in the risk of diabetes among participants based on their BMI status. Underweight participants had 11.4% at low risk, 78.1% at moderate risk, and 10.5% at high risk of diabetes, indicating a relatively lower presence of high-risk cases. Participants with normal weight had slightly higher proportions, with 13.3% at low risk, 66.0% at moderate risk, and 20.8% at high risk. Overweight individuals showed a notable shift towards higher diabetes risk, with 5.7% at low risk, 65.4% at moderate risk, and 28.9% at high risk. This trend continued with participants in Obesity Class I, where 6.3% were at low risk, 65.3% at moderate risk, and 28.4% at high risk, reflecting a strong association between increasing BMI and elevated diabetes risk.

Notably, participants in Obesity Class II exhibited the most concerning figures, with only 3.4% at low risk, 57.3% at moderate risk, and a significant 39.3% at high risk, underscoring the critical impact of severe obesity on diabetes prevalence. Overall, the findings demonstrated a clear trend: as BMI increased, so did the proportion of participants at high risk of diabetes. These differences in diabetes risk across BMI categories were statistically significant, with a p-value < 0.001.

**Table 11: Comparison of Risk of Diabetes as per IDRS based on the Comorbidity status of the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
Comorbidities	Present	35	4.7%	447	60.0%	263	35.3%	<0.001*
	Absent	145	9.7%	1014	67.8%	337	22.5%	

\* - Statistically Significant

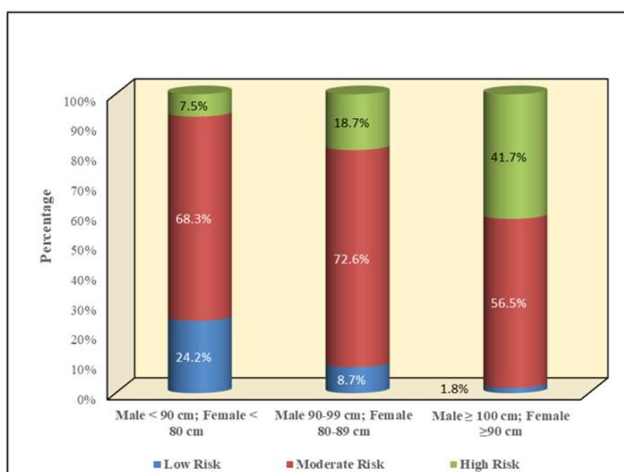
Among participants with comorbidities, 4.7% were at low risk, 60.0% were at moderate risk, and 35.3% were at high risk of diabetes. This distribution showed a substantial presence of high-risk cases, emphasizing the increased diabetes risk associated with existing comorbidities. In contrast,

participants without comorbidities had a higher percentage at low risk (9.7%), with 67.8% at moderate risk and 22.5% at high risk. Although the majority were still at moderate risk, the high-risk category was considerably lower compared to participants with comorbidities. Overall, these findings indicated that the presence of comorbidities significantly heightened the risk of diabetes, with those having comorbidities facing a higher proportion of high-risk for developing diabetes. This difference was statistically significant, with a p-value < 0.001, highlighting the critical impact of comorbidities on diabetes risk.

**Table 12: Comparison of Risk of Diabetes as per IDRS based on the Waist Circumference of the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
Waist circumference	Male < 90 cm; Female < 80 cm	78	24.2%	220	68.3%	24	7.5%	<0.001*
	Male 90-99 cm; Female 80-89 cm	85	8.7%	709	72.6%	183	18.7%	
	Male ≥ 100 cm; Female ≥ 90 cm	17	1.8%	532	56.5%	393	41.7%	

\* - Statistically Significant



**Fig. 6: Comparison of Risk of Diabetes as per IDRS based on the Waist Circumference of the study participants using Chi Square Test**

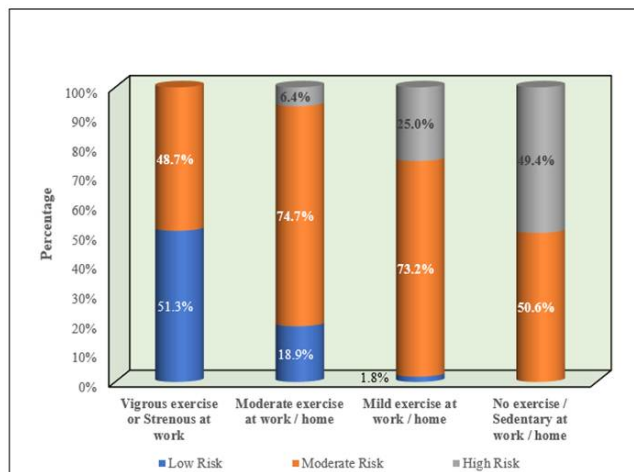
The comparison of the risk of diabetes based on waist circumference reveals significant differences across the different risk groups. Among individuals with a waist circumference less than 90 cm for males and less than 80 cm for females, the majority, 68.3% (n=220), fall into the moderate risk category, with 24.2% (n=78) in the low risk category and 7.5% (n=24) in the high risk category. For those

with a waist circumference between 90-99 cm for males and 80-89 cm for females, a smaller percentage, 8.7% (n=85), are in the low risk category, while 72.6% (n=709) are at moderate risk and 18.7% (n=183) at high risk. In contrast, individuals with a waist circumference of 100 cm or more for males and 90 cm or more for females have the highest proportion in the high risk category, with 41.7% (n=393) in high risk, only 1.8% (n=17) in low risk, and 56.5% (n=532) in moderate risk. These findings highlight that as waist circumference increases, the proportion of individuals at high risk of diabetes also increases significantly. The differences observed between the risk groups based on waist circumference were statistically significant ( $p < 0.001$ ).

**Table 13: Comparison of Risk of Diabetes as per IDRS based on the Physical Activity of the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
Physical activity	Vigorous exercise or Strenuous at work	60	51.3%	57	48.7%	0	0.0%	<0.001*
	Moderate exercise at work /home	104	18.9%	410	74.7%	35	6.4%	
	Mild exercise at work /home	16	1.8%	639	73.2%	218	25.0%	
	No exercise / Sedentary at work/home	0	0.0%	355	50.6%	347	49.4%	

\* - Statistically Significant



**Fig. 7: Comparison of Risk of Diabetes as per IDRS based on the Physical Activity of the study participants using Chi Square Test**

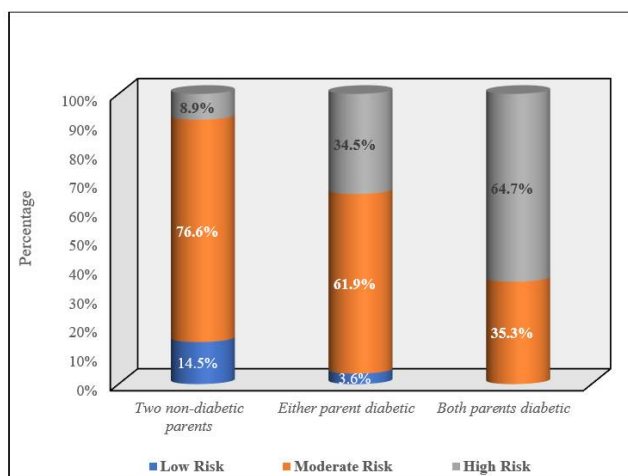
The comparison of the risk of diabetes based on physical activity reveals significant differences across different risk groups. Individuals who engage in vigorous exercise or have

strenuous work show that 51.3% (n=60) are at low risk, 48.7% (n=57) are at moderate risk, and none are at high risk. Those who do moderate exercise at work or home have 18.9% (n=104) at low risk, 74.7% (n=410) at moderate risk, and 6.4% (n=35) at high risk. For individuals doing mild exercise at work or home, only 1.8% (n=16) are at low risk, 73.2% (n=639) are at moderate risk, and 25.0% (n=218) are at high risk. In contrast, individuals with no exercise or sedentary work or home lifestyle show that none are at low risk, 50.6% (n=355) are at moderate risk, and 49.4% (n=347) are at high risk. These findings highlight that higher physical activity levels are associated with lower diabetes risk, while low or no physical activity significantly increases the risk of diabetes. The differences observed between the risk groups based on physical activity were statistically significant ( $p < 0.001$ ).

**Table 14: Comparison of Risk of Diabetes as per IDRS based on the Family History of Diabetes among the study participants using Chi Square Test**

Variable	Category	Low Risk		Moderate Risk		High Risk		p-value
		n	%	n	%	n	%	
Family history of diabetes	Two non-diabetic parents	145	14.5%	767	76.6%	89	8.9%	<0.001*
	Either parent diabetic	35	3.6%	597	61.9%	333	34.5%	
	Both parents diabetic	0	0.0%	97	35.3%	178	64.7%	

\* - Statistically Significant



**Fig. 8: Comparison of Risk of Diabetes as per IDRS based on the Family History of Diabetes among the study participants using Chi Square Test**

The comparison of the risk of diabetes based on family history reveals significant differences across different risk groups. Among individuals with two non-diabetic parents, 14.5%

(n=145) are at low risk, 76.6% (n=767) are at moderate risk, and 8.9% (n=89) are at high risk. For those with either parent diabetic, a smaller percentage, 3.6% (n=35), are at low risk, 61.9% (n=597) are at moderate risk, and a much higher percentage, 34.5% (n=333), are at high risk. In contrast, individuals with both parent diabetic show that none are at low risk, 35.3% (n=97) are at moderate risk, and a significantly higher percentage, 64.7% (n=178), are at high risk. These findings indicate that a family history of diabetes significantly increases the risk of diabetes, with the highest risk observed in individuals with both parents' diabetic. The differences observed between the risk groups based on family history were statistically significant ( $p < 0.001$ ).

## 4 Discussion

Non-Communicable Diseases (NCDs) contribute to 74% of global deaths, with a significant burden in low- and middle-income countries (77%) (World Health Organization). Diabetes, a major NCD, is of increasing concern in India. Our study in Kerala, with 2241 participants aged 16 to 89 years, assessed diabetes risk using the Indian Diabetic Risk Score (IDRS). Results showed 26.8% of participants at high risk of diabetes. Comparatively, studies from other Indian cities reported higher high-risk proportions: Meerut (33.4%), Delhi (39.6%), Pune (36.5%), Urban Chennai (43%), Hyderabad (38%), and Tripura (34.2%). A multidomain study across India reported a high-risk prevalence of 40.9%.

The study found diabetes risk increases with age. Participants aged 18–84 (mean age  $42.88 \pm 12.06$  years) were at high risk, while those aged 17–89 (mean age  $34.90 \pm 11.55$  years) were at moderate risk ( $p = 0.001$ ). Supporting studies, such as one from Andhra Pradesh, showed similar trends with 37% of high-risk individuals aged 36–50 years and 21% above 50 years. Acharya *et al.* (2017)<sup>(1)</sup> reported 75% of participants aged 30–49 years, with an overall mean age of  $43.38 \pm 11.26$  years.

Educational qualifications were not statistically significant in determining diabetes risk ( $p = 0.63$ ). However, 34.9% of participants were illiterate, underscoring the need for targeted awareness interventions. Namdev *et al.*<sup>(8)</sup> reported literacy rates of 58.1% and 67.8%, and Halder *et al.* found one-third of participants illiterate (29.5%).

Waist circumference (WC), an indicator of abdominal obesity, was significantly associated with diabetes risk ( $p < 0.001$ ). Anand *et al.*<sup>(2)</sup> observed gender differences: 42.1% of males and 51.4% of females had WC above the threshold for central obesity. Acharya *et al.*<sup>(1)</sup> reported similar patterns, with 42% of participants showing central obesity. This highlights the need for interventions addressing obesity and related health risks.

Physical activity showed a significant impact on diabetes risk. Only 5.2% of participants engaged in vigorous activity, while 68.5% performed mild to moderate activity, and 31.3% led

sedentary lifestyles. Vigorous activity participants had no high-risk cases, while sedentary participants showed 49.4% at high risk ( $p < 0.05$ ). Similar patterns were noted in studies by Singh *et al.* and Anand *et al.*<sup>(2,7)</sup>.

Participants were categorized by BMI: 5.1% underweight, 27.9% normal, 22.7% overweight, 32.4% Obesity Class I, and 11.9% Obesity Class II. Obesity significantly increased diabetes risk, consistent with studies by Sri PKSSU *et al.*, Dugg *et al.*, and Gupta *et al.* Associations were observed between diabetes risk and factors such as BMI, gender, and diet ( $p < 0.05$ )<sup>(12,14)</sup>.

A family history of diabetes significantly influenced risk. Participants with no family history had 8.9% high risk, compared to 34.5% with one diabetic parent and 64.7% with both diabetic parents ( $p < 0.001$ ). Comorbidities also increased high-risk proportions to 35.3%, compared to 22.5% without comorbidities.

Using IDRS, 34% of participants were at high risk, consistent with Sri PKSSU *et al.* and Brahmabhatt (34%)<sup>(14)</sup>. This was higher than Arun *et al.* (14.9%) and Panda *et al.* (17.9%) but lower than Mani *et al.* (59%). Moderate-risk participants (45.4%) were comparable to Gupta *et al.* but lower than Sowmiya *et al.* (50.9%)<sup>(12)</sup>.

Indian dietary pattern is highly variant and region-specific ranging from strict vegetarian or vegan diet to addition of sweets, savoury snacks, meats and other high fat, sugar salt containing foods. Individuals who have large portion meals, generally exceeding 30% of the requirement are more at risk of obesity. Asian Indians being at increased risk of developing diabetes and CVDs at lower BMIs should have a self-regulated intake pattern to regulate the portion size<sup>(3,4,9-11)</sup>.

### 4.1 Implications for Public Health

This study highlights the urgent need for large-scale diabetes prevention strategies in Kerala. Key recommendations include:

- 1. Community-Based Screening:** Implementing IDRS as a routine screening tool in community health programs to identify at-risk individuals early.
- 2. Lifestyle Interventions:** Promoting physical activity, balanced diets, and weight management through awareness campaigns and community initiatives.
- 3. Targeted Educational Programs:** Developing tailored educational interventions for illiterate and less-educated populations to improve diabetes literacy.
- 4. Policy Advocacy:** Leveraging the findings to advocate for diabetes prevention policies that address region-specific risk factors, including dietary habits and urbanization.

**5. Integrated Care Models:** Addressing comorbidities and providing comprehensive care to at-risk individuals to mitigate long-term complications.

In conclusion, the use of IDRS provides valuable insights into diabetes risk in Kerala, highlighting key areas for intervention. By addressing the identified risk factors through targeted

public health actions, Kerala can significantly reduce its diabetes burden and improve population health outcomes.

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