

Assessment of Cardiovascular Risk Factors, Dietary Patterns & Physical Activity Level among People with Young Onset Diabetes in a Tertiary Care Setting in Sri Lanka

Pathirana N. S. W¹, Fahmiya F. A. F², Sumanatilleke M. R¹, Bulugahapitiya U¹, Arambawela M. H³

¹ Diabetes and Endocrine Unit, National Hospital of Sri Lanka

² British College of Applied Sciences

³ Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka

Abstract

Introduction:

Globally, there is a rising trend in young-onset diabetes (YOD) prevalence, with type 1 diabetes (T1DM) contributing to the majority. However, in recent years, type 2 diabetes (T2DM) has had a notable impact on YOD prevalence. Diabetes is considered a cardiovascular disease equivalent. This is further compounded by obesity-associated insulin resistance (IR). With the increasing prevalence of YOD and longer life expectancy, assessing and addressing cardiovascular disease (CVD) risk in this population has gained importance. In this study, we aimed to determine the presence of CVD risk factors in a YOD population.

Methods:

A descriptive, cross-sectional study was carried out among people with YOD attending a specialised clinic in a tertiary care centre. Traditional CVD risk factors, including anthropometric measures and exercise and dietary habits, were assessed. Data analysis was done using SPSS.

Results:

The study included 95 participants, 54.7% (n=52) females, with a mean age of 23.8 ± 6.2 years and an average diabetes duration of 7.0 ± 5.9 years. Among the participants, 63% had T1DM, and 24% had T2DM. The mean age of disease onset was 17.0 ± 4.5 years. The prevalence of microvascular complications was as follows: retinopathy 12.7% (n=12), nephropathy 5.3% (n=5), and neuropathy 4.7% (n=4). One patient (1%) had ischemic heart disease.

The population's mean BMI was 21.59 ± 4.58 kg/m², with 12% (n=11) overweight and 25% (n=24) obese participants. In the population, 34% (n=32) had dyslipidemia, 10% (n=9) had hypertension, and 7% (n=6) were smokers.

A total of 78% (n=18) of T2DM patients and 16.7% (n=10) of T1DM patients were classified as either overweight or obese. Both males and females with T2DM had higher waist circumference (WC) and waist-to-height ratios (WHR) compared to their specific gender with T1D ($p < 0.05$). Among T1DM patients, females had higher WC and WHR than males. However, only female T2DM patients exceeded the safe thresholds for WC and WHR. Percentage prevalence of anthropometric risk factors, high LDL and Low HDL were highest in females with T2DM; the average daily intake of carbohydrates was 214g. The contribution of carbohydrates to the daily macronutrient content in the diet was 62% in T1DM and 76% in T2DM. Despite 71% of the population consuming vegetables daily, only a quarter of the participants consumed fruit. None of the study participants met the daily recommended physical activity levels.

Conclusion:

While the prevalence of anthropometric risk factors for cardiovascular disease is higher in T2DM patients, it is also prevalent in a significant proportion of T1DM patients, with a female predominance in both groups. Additionally, the study's findings underscore the importance of addressing lifestyle factors like diet and exercise and optimising cardiovascular risk reduction strategies in YOD populations to tackle the CVD risk regardless of the type of diabetes.

Keywords: young-onset diabetes, cardiovascular risk factors, diet, exercise

Correspondence email: nethranipathirana@gmail.com

ORCID ID: <https://orcid.org/0000-0003-2300-7574>

Copyright: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. (CC BY 4.0)

Introduction

The International Diabetes Federation reported a global diabetes prevalence of 10.5% (536.6 million people) in 2021, projected to rise to 12.2% (783.2 million) by 2045 among adults (age 20–79 years). The most significant increase is expected in low & middle income countries like Sri Lanka. This is also reflected in South Asian projections, where diabetes prevalence is anticipated to grow from 90 million in 2021 to 151 million by 2045^[1].

While most new diabetes cases are T2DM in older adults, diabetes prevalence is also rising among younger individuals. The majority of diabetes in youth is due to T1DM by nature. The age cutoff for "young-onset diabetes" varies between studies and usually denotes young-onset T2DM. Early-onset T2DM typically includes adults under 40, while youth-onset diabetes is defined as occurring before age 25.^[2] The global obesity pandemic is a leading causative factor in the rising prevalence of T2DM in young people. Ethnicity also influences the type of diabetes, where South Asian ethnicity and associated IR may predispose to the development of T2DM at an earlier age. This is further reflected in an Indian study that indicates nearly equal prevalence of T1DM and T2DM in young adults.^[3,4] Additionally, other forms like maturity-onset diabetes of the young (MODY), pancreatic diabetes (T3cD) and diabetes occurring due to medication and syndromes also contribute to aetiology in YOD.

Diabetes is considered a cardiovascular disease equivalent^[5,6]. However, hyperglycaemia per se is a weak risk factor for cardiovascular disease, as evidenced by the UKPDS trial, where intensive glycaemic control took nearly ten years to reduce CVD risk^[7,8]. Instead, CVD risk in diabetes is cumulative and influenced by several factors beyond glycaemic control. In diabetes, insulin resistance associated with obesity leads to dyslipidaemia, hypertension, endothelial dysfunction, a procoagulant state, and metabolic syndrome, contributing to this increased CVD risk.^[9]

Numerous studies have demonstrated the importance of South Asian ethnicity as a risk-enhancing factor.^[10,11] The underlying mechanism is believed to involve abdominal obesity and associated insulin resistance, exacerbated by urbanization-related lifestyle changes, such as increased calorie-dense refined food consumption and reduced physical activity.^[11] Recent study done in Sri Lanka have revealed a prevalence of 23% of T2DM and 30.5% of pre-diabetes among adults.^[12] Interestingly, high diabetes and pre-diabetes prevalence noted among normal BMI individuals in this study further denote the intricacies of other underlying mechanisms, including IR and abdominal obesity in the pathogenesis of diabetes while indicating BMI might not be the ideal measure of obesity or the future risk of obesity-related complications.^[12]

The recent obesity epidemic has led to insulin resistance, even among people with T1DM. This has given rise to the phenomenon known as "double diabetes", where even people with T1DM have complications associated with obesity and insulin resistance^[13,14].

There is ample evidence that people with young diabetes, whether type 1 or type 2, face heightened CVD risk, which worsens as they age. The resulting morbidity and mortality add significantly to the socioeconomic burden and the reduced quality of life of the individual. Therefore, focusing on CVD risk

reduction should be a priority early on. However, at the same time, accurate identification of those at risk to avoid overtreatment is also important. Thus, regular assessment of CVD risk factors in young people with diabetes to identify the cohort that requires risk factor modification is essential to tackle this ever-growing problem.

Traditionally, BMI has been used to define obesity. However, it is not an ideal measure of visceral adiposity, which is the main causative factor for obesity-related complications. Thus, several other simple anthropometric measures, such as waist circumference, waist-height ratio and waist-hip ratio, can be used to predict visceral adiposity in a clinical setting. Additionally, body impedance analysers, dual-energy absorptiometry and various imaging techniques are emerging as new ways to increase the accuracy of visceral fat estimation in a research setting.^[15]

Though many studies have been conducted on adults with diabetes, there is a significant deficit of literature on YOD. Therefore, we aimed to assess the traditional CVD risk factors, including anthropometric measures, exercise, and dietary habits of people with YOD who were followed up at a tertiary care centre in Sri Lanka through this study. We hoped to find the prevalence of CVD risk factors and areas that can be targeted in risk reduction strategies.

Methodology

This descriptive cross-sectional study was conducted at the specialised clinic for YOD at the Endocrine and Diabetes Unit, National Hospital Sri Lanka. The clinic cared for young people (between 14 and 25 years of age) with diabetes diagnosis, irrespective of the etiological category.

All patients registered in the clinic between August 1st, 2022, and February 28th, 2023, were enrolled in the study. Pregnant patients were excluded. Informed written consent was obtained from patients >18 years of age. Assent consent was obtained from patients in the 14–18 age group. Ethical clearance was obtained from the ethical review committee of the Faculty of Medical Sciences, University of Sri Jayewardenepura.

Socio-demographic data was obtained by interviewer-administered questionnaire. Disease-related data, including blood investigations, were obtained from the YOD in Sri Lanka (DYOD-SL) database and patients' health records.

Height and weight were measured using standard World Health Organization techniques. Body weight was recorded to the nearest 0.1 kg using calibrated electronic scales. Height was measured with a portable stadiometer to the nearest millimetre. BMI was categorised using Asian cut-offs: Underweight (<18.5), Normal (18.5–22.9), Overweight (23–24.9), Obesity Class 1 (25–29.9), Obesity Class 2 (30–34.9), and Obesity Class 3 (>35).^[16] The waist circumference was measured to the nearest millimetre with a flexible tape placed midway between the ribs and iliac crest, ensuring a snug but not compressive fit.

Total body fat and visceral fat percentages were determined using a Body Fat Analyzer (Bioimpedance Analyzer—OMRON HBF 362). Fat percentages were recorded to the nearest 0.1%.

Data on the patients' physical activities were obtained using a validated questionnaire, the International

Physical Activity Questionnaire(IPAQ).^[17] IPAQ measures the time per week spent on moderate or vigorous physical activity in different aspects of life (work, leisure, household tasks, etc.). The total minutes spent engaging in moderate-intensity and high-intensity exercises were calculated at the end of the questionnaire. Then, it was converted to metabolic equivalent(MET) minutes by multiplying the MET value of each activity. One metabolic equivalent (MET) is the energy it takes to sit quietly per minute. When interpreting IPAQ, walking is considered to be 3.3 METS, moderate physical activity is 4 METS, and vigorous physical activity is 8 METS.^[18]

The methodology for collecting food habits data followed the same approach as the Sri Lankan study on food consumption among adults.^[19] An interviewer-administered questionnaire was used to gather data on 24-hour dietary recall. Patients were asked to chronologically recall their food intake in the past 24 hours. Food portion sizes were determined using standard household measures like plates, bowls, cups, glasses, and spoons. To ensure accuracy, participants were shown real utensils and a series of food portion-size photographs from the Food Atlas and Carb Counter for people with diabetes. These documents were used to calculate the macronutrient composition of each meal, and subsequently, daily consumption was calculated.^[20,21] If participants recalled food amounts by weight, these values were recorded.

Data was analysed using SPSS version 26. Mean and standard deviation or frequency and percentage were used for descriptive analysis. The study groups were compared using the chi-square test (for categorical data) or t-test(to compare means). The significance level (P value) was considered less than 0.05.

Results

The study population included 95 patients with YOD, defined as the development of diabetes before the age of 25. Of this population, 54.7%(n=52) were females, with a mean age of 23.8 ± 6.2 years and an age range of 16-33 years. The mean age of disease onset was 17.0 ± 4.5 years, and the average duration of diabetes was 7.0 ± 5.9 years. Additionally, 25.5%(n=24) of patients had been living with diabetes for over ten years.

In the study population, 63% (n=60) were diagnosed with T1DM, while 24% (n=23) had T2DM. Maturity-onset diabetes of the young (MODY), pancreatic diabetes and syndrome-related diabetes accounted for 13% (n=12) of the population. Despite the study population having multiple etiologies for YOD, group comparisons were made between the T1DM and T2DM groups only.

Disease-related long-term complications

There was no history of stroke or peripheral vascular disease in the study participants. In the overall study population, only one person (1%) had a history of ischemic heart disease. She was a T1DM patient who had 15 years of disease duration and had all the other microvascular complications as well. The microvascular complications were more prevalent: retinopathy 12.7% (n=12), nephropathy 5.3%(n=5) and neuropathy affected 4.7%(n=4) of the patients. There was no statistically significant difference in microvascular complications between patients with young onset T1DM and T2DM.

Anthropometry, body fat indices and other CVD risk factors

The mean BMI of the study population was 21.59 ± 4.58 kg/m². Thirty-six per cent (n=34) had a normal BMI, 27% (n=26) were underweight, 12% (n=11) were overweight, and 25% (n=24) were obese.

Among young-onset T2DM patients, 56% (n=13) were obese, and 22% (n=5) were overweight, and none were underweight. In contrast, in the T1DM group, 16.7% (n=10) were obese or overweight, and 39% (n=23) were underweight. Figure 1 shows the distribution of patient percentages in T1DM and T2DM groups among BMI categories. Overweight and obesity in the T2DM population, which showed a statistically significant difference (p-value <0.05) compared to T1DM, there was a substantial percentage of underweight patients in the T1DM population(p-value<0.05).

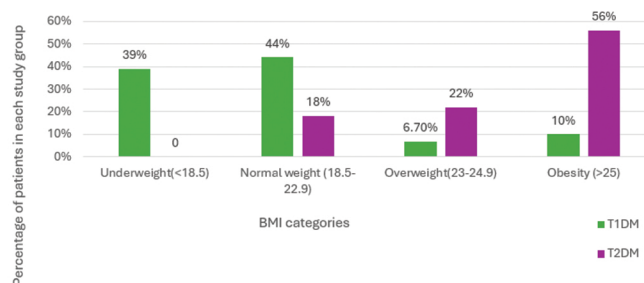


Figure 1: Distribution of participants of T1DM and T2DM groups among BMI categories

As noted in Table 1, only female T2DM patients had mean waist circumference and WHR above the cutoff values. Both genders in the T1DM group had statistically significant lower mean waist circumferences and WHR compared to their T2DM counterparts. With regard to the fat percentage measured by the bioimpedance analyser, a statistically significant difference was observed with body fat and visceral fat percentage in females where T2DM females had higher values.

In addition to the highest prevalence of anthropometric risk factors in T2DM females, they had the highest prevalence of high LDL and low HDL. When compared with the male T2DM patients, the risk factor prevalence in female T2DM patients was almost two times higher, and for low HDL and high waist circumference, it was nearly four to six times higher.

When comparing T1DM females and males, females suffered from higher percentage prevalence of high waist circumference, WHR and hypertension, but the difference was not as marked as in the T2DM group.

The prevalence of other CVD risk factors in the study population as a whole was as follows: 33.6% had dyslipidemia(n=32), 9.5% had hypertension(n=9), and 7.3% (n=7)were smokers.

Table 1: Comparison of anthropometric parameters and body fat indices among patients with type 1 and type 2 diabetes divided according to gender

Measure	Type 1 diabetes		Type 2 diabetes		Significance (p<0.05)
	Male	Female	Male	Female	
Mean Waist circumference (cm) (gender-specific waist cutoff)	72.2 (90cm)	72.2 (80cm)	87.8 (90cm)	81.4 (80cm)	Males: p< 0.05* Females: p< 0.05*
Mean Waist/Height ratio (WHR) (normal < /= 0.5)	0.43	0.46	0.50	0.52	Males: p< 0.05* Females: p< 0.05*
	0.45		0.51		P <0.05**
Mean Body Fat %	17.9	28.5	24.6	31.8	Males: p=0.105* Females: p<0.05*
Mean Visceral Fat %	4.12	3.08	6.26	6.83	Males: p=0.353* Females: p< 0.05*

*comparison was between males/females with T1DM vs males/females with T2DM

**comparison was between T1DM and T2DM groups

Table 2: Per centage prevalence of cardiovascular risk factors in T1DM and T2DM groups according to the gender

Risk Factors	T1DM		T2DM	
	Male	Female	Male	Female
Overweight/Obesity BMI> 23	9.37% (n=3)	7.14% (n=2)	25.0% (n=3)	54.50% (n=6)
High WC- Males > 90cm, Females: > 80cm	3.12% (n=1)	14.28% (n=4)	8.33% (n=1)	36.32% (n=4)
Waist/ Height Ratio >0.5	6.25% (n=2)	10.71% (n=3)	16.66% (n=2)	45.40% (n=5)
Hypertension	6.25% (n=2)	7.14% (n=2)	8.33% (n=1)	0%
Smoking	9.37% (n=3)	0%	8.33% (n=1)	0%
LDL>100mg/dl	24.98% (n=8)	21.42% (n=6)	16.66% (n=2)	45.40% (n=5)
HDL<60mg/dl	21.86% (n=7)	14.28% (n=4)	8.33% (n=1)	54.50% (n=6)

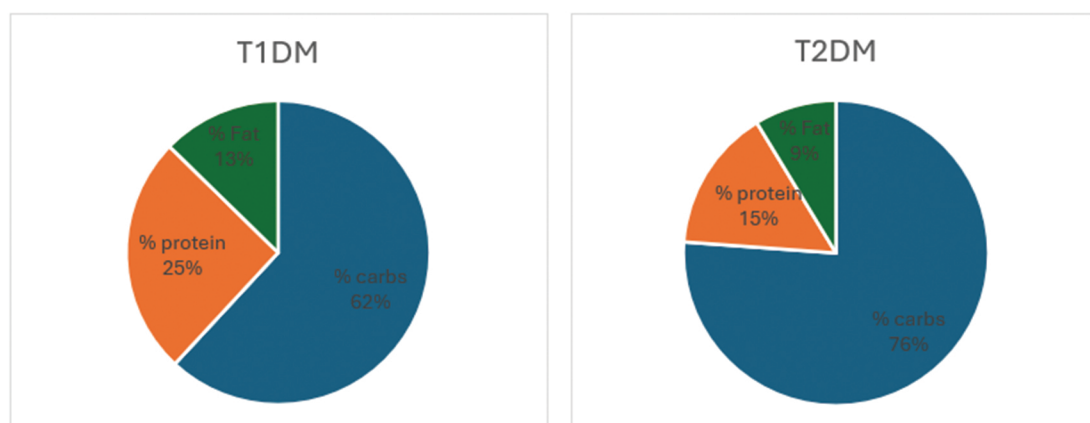


Figure 2: Comparison of Macronutrient Composition in Daily Diets of Individuals with T1DM and T2DM among Overall Population of YOD.

Glycemic control

The mean HbA1c for the overall population was 9.65%. Among T1DM and T2DM patients, the mean HbA1c levels were 9.6% and 9.7%, respectively. In this young diabetic population, only 16.6% (n=16) of patients achieved a target HbA1c level of <7%.

In the study population, 80% (n=76) received insulin alone or in combination with oral hypoglycaemic agents (OHA), 17% (n=17) of whom were T2DM patients, and the remaining 20% (n=19) received only OHA.

Lifestyle factors

None of the study participants engaged in vigorous activities. However, 37.7% of the patients reported engaging in moderate-intensity activities for an average of 2 days per week, with a mean duration of 27 ± 16.8 minutes. The mean daily walking time was 3.2 ± 1.06 hours, encompassing walking at work and home for transportation, recreation, exercise, sport, or leisure. Regarding sedentary behaviour, the mean sitting time on a weekday was 5.1 ± 2.4 hours.

Based on the 24-hour dietary recall results, the patients in the study group had an average daily intake of 214.2 ± 50.2 g of carbohydrates, 61.5 ± 18.4 g of protein, and 30.8 ± 9.5 g of fat per person. About 71% of the patients included vegetables in their daily meals. Only 24.4% included fruits in their daily meals. Carbohydrate intake was highest during lunch (65.18 ± 22.96 g) compared to breakfast (62.425 ± 22.12 g) and dinner (60.52 ± 24.68 g). Regarding dairy intake, 60% of the population consumed milk or milk added to coffee or tea at least once daily, while dairy products like cheese, yoghurt, and butter were less frequently consumed.

Discussion

Disease duration is one of the most important risk factors for the development of micro and macrovascular complications of diabetes. The impact of glycaemic control on macrovascular complications, notably cardiovascular morbidity, takes longer to appear than microvascular complications.^[7,8] With nearly a quarter of the study population having diabetes for over ten years and an average disease duration of 7 years, the study has a significantly at-risk population for cardiovascular morbidity and provides an ideal platform for the assessment of known cardiovascular risk factors in the absence of CVD morbidity at the moment. Despite the extended duration of diabetes, only 1% of the study population suffered from ischemic heart disease. This low prevalence may be a result of the relatively young age of the study population because age is a decisive risk factor for developing IHD.^[22] It is important to note that the benefit of lifelong management of risk factors is more significant in younger individuals with diabetes to prevent future CVD morbidity and mortality as they age. This contrasts with the more common occurrence of microvascular complications in our study population, providing additional evidence that microvascular complications tend to develop earlier than macrovascular complications.

A quarter of the study population were underweight, all being people with T1DM. Possible reasons for this finding include poor diabetes control, as indicated by the average HbA1c of close to 10%, and the majority being from low-to-middle socioeconomic classes, suggesting malnutrition as a potential contributing

factor. Poor diabetes control is a challenging clinical issue, especially in T1DM patients, where the delicate balance between stringent control of glycemia and the risk of life-threatening hypoglycemia may be difficult to achieve. However, optimising management strategies with better insulin regimens, more frequent glucose monitoring, empowering patients to self-manage their diabetes, and using advanced technology would pave the way to improving care in T1DM in the future.

As outlined in the famous Banting lecture in 2009, insulin resistance (IR) is the central pathophysiological change in the development of T2DM.^[9] Hence, it is not unusual to observe that the prevalence of obesity and overweight is higher in the subpopulation of T2DM patients, as they contribute significantly to the IR.

In this study of young people with diabetes, the T2DM group exhibited numerically higher BMI, waist circumference, and waist/height ratio than the T1DM group. However, 8.3% of T1DM patients also had above-target waist circumference and waist/height ratio, and were either overweight or obese. Across both groups, more females displayed high-risk anthropometric measurements than males, especially with regard to the indirect indicators of visceral adiposity, such as WC and WHR. This finding contrasts the well-known fact that males have higher visceral fat than females^[15,23]. But, at the same time, we should keep in mind that neither anthropometric measures nor bioimpedance analysis are hundred per cent accurate when measuring visual adiposity.

With the ongoing obesity epidemic, IR is increasingly observed even in T1DM patients, leading to the term "double diabetes". IR is associated with the emergence of cardiometabolic conditions such as dyslipidemia, low-grade inflammation, endothelial dysfunction, and hypertension. These conditions act as underlying factors that heighten the risk of atherosclerosis and cardiovascular disease.^[9] Prevalence of obesity and overweight in the subpopulation of T1DM patients further confirms this fact. It highlights the need for active interventions to prevent further rising prevalence as well as the need to target this overweight/obesity population for additional cardiovascular risk reduction strategies.

Physical inactivity is a well-established lifestyle risk factor for the development of IR. Alarming, in this young diabetic population, none of the patients adhered to the WHO-recommended physical activity level of 150–300 minutes of moderate-intensity aerobic physical activity or at least 75–150 minutes of vigorous-intensity aerobic physical activity. Additionally, at least one-quarter of the day is spent seated, indicating a sedentary lifestyle prevalent among these individuals.

A typical South Asian meal is characterised by high carbohydrate content with a high glycemic index, as demonstrated in this study, where 60–70% of daily macronutrients consist of carbohydrates (T1DM- 62% and T2DM 76%). Most of the study population, being T1DM patients, relied on carbohydrate counting for insulin dosing and had dietary modifications, including the plate model advising to restrict carbohydrate content to $\frac{1}{4}$ of the plate and to increase the green leafy vegetables to at least half of the plate. Other diabetes patients were also regularly informed on the nutritional modifications recommending carbohydrate restriction. Nevertheless, this population's intake of different macronutrients and dairy products was subpar. These dietary patterns may be attributed to financial constraints among the population tested and patient inertia towards change.

Lastly, regular measurement of anthropometric parameters (such as waist circumference, waist to height ratios) can serve as a cost-effective method to assess insulin resistance, visceral adiposity and guide therapies aimed at reducing it. However, it's essential to reinforce measures to improve physical activity levels and implement dietary modifications tailored to the underlying illness in this population. These interventions may ultimately impact the CVD outcomes of this young diabetic population.

Limitations

The diagnosis of T1DM was based predominantly on clinical features and c-peptide levels. The antibody status of suspected T1DM patients was determined only when the patient's personal financial status allowed. The small sample size is a major limiting factor in our current study. The study focused on patients under 25, but potential selection bias must be noted. The specialised clinic primarily served diabetic patients under 25, capturing nearly all T1DM cases, but young T2DM patients might not have been consistently followed up in this specialised clinic. This may result in an overrepresentation of T1DM and an underrepresentation of T2DM.

Body fat measurement using dual-energy X-ray absorptiometry is more accurate than using a bioimpedance analyser. However, due to limited resources, we were unable to utilize it.

Conclusion

In this study among young diabetic patients, assessment of cardiovascular risk factors indicated that anthropometric parameters signalling CVD risk are more prevalent in those with T2DM. Yet, they are also observed in a portion of patients with T1DM. A suboptimal diet and exercise patterns noted in these patients can further enhance the risk while impeding risk reduction. Implementing a program addressing these factors could lead to significant benefits in optimising the cardiovascular health of this population in the long run.

References

- Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract* [Internet]. 2022 Jan 1 [cited 2024 Apr 6];183. Available from: <http://www.diabetesresearchclinicalpractice.com/article/S0168822721004782/fulltext>
- 32 | Management of type 2 diabetes: A handbook for general practice.
- Sahoo S, Zaidi G, Vipin V, Chapla A, Thomas N, Yu L, et al. Heterogeneity in the aetiology of diabetes mellitus in young adults: A prospective study from north India. *Indian J Med Res* [Internet]. 2019 Apr 1 [cited 2024 Apr 6];149(4):479. Available from: <https://pubmed.ncbi.nlm.nih.gov/36676834/>
- Dabelea D, Mayer-Davis EJ, Saydah S, Imperatore G, Linder B, Divers J, et al. Prevalence of Type 1 and Type 2 Diabetes Among Children and Adolescents From 2001 to 2009. *JAMA* [Internet]. 2014 May 7 [cited 2024 Apr 6];311(17):1778–86. Available from: <https://jamanetwork.com/journals/jama/fullarticle/1866098>
- Haffner SM, Lehto S, Rönnemaa T, Pyörälä K, Laakso M. Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction. *N Engl J Med* [Internet]. 1998 Jul 23 [cited 2024 Jun 4];339(4):229–34. Available from: <https://pubmed.ncbi.nlm.nih.gov/9673301/>
- Bloomgarden ZT. Diabetes and cardiovascular disease. *Diabetes Care* [Internet]. 2011 Mar [cited 2024 Jun 4];34(3). Available from: <https://pubmed.ncbi.nlm.nih.gov/21357355/>
- Turner R. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* [Internet]. 1998 Sep 12 [cited 2024 Apr 8];352(9131):837–53. Available from: <http://www.thelancet.com/article/S0140673698070196/full-text>
- Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HAW. 10-Year Follow-up of Intensive Glucose Control in Type 2 Diabetes. *New England Journal of Medicine* [Internet]. 2008 Oct 9 [cited 2024 Apr 8];359(15):1577–89. Available from: <https://www.nejm.org/doi/full/10.1056/nejmoa0806470>
- Defronzo RA. From the Triumvirate to the Ominous Octet: A New Paradigm for the Treatment of Type 2 Diabetes Mellitus. *Diabetes* [Internet]. 2009 Apr 1 [cited 2024 Apr 8];58(4):773–95. Available from: <https://dx.doi.org/10.2337/db09-9028>
- Patel AP, Wang M, Kartoun U, Ng K, Khara A V. Quantifying and understanding the higher risk of atherosclerotic cardiovascular disease among South Asians — results from the UK Biobank prospective cohort study. *Circulation* [Internet]. 2021 Aug 8 [cited 2024 Apr 8];144(6):410. Available from: <https://pubmed.ncbi.nlm.nih.gov/34835517/>
- Gupta M, Brister S. Is South Asian ethnicity an independent cardiovascular risk factor? *Can J Cardiol* [Internet]. 2006 Mar 1 [cited 2024 Apr 8];22(3):193. Available from: <https://pubmed.ncbi.nlm.nih.gov/162528919/>
- Prasan Rannan-Eliya R, Wijemunige N, Perera P, Kapuge Y, Gunawardana N, Sigera C, et al. Prevalence of diabetes and pre-diabetes in Sri Lanka: a new global hotspot-estimates from the Sri Lanka Health and Ageing Survey 2018/2019 Prevalence of diabetes and pre-diabetes in Sri Lanka: a new global hotspot-estimates from the Sri Lanka Health and Ageing Survey 2018/2019. *BMJ Open Diab Res Care* [Internet]. 2023 [cited 2024 Jun 17];11:3160. Available from: <https://bmjopen.bmj.com/>
- Bielka W, Przekaz A, Moleda P, Pius-Sadowska E, Machaliński B. Double diabetes—when type 1 diabetes meets type 2 diabetes: definition, pathogenesis and recognition. *Cardiovascular Diabetology* 2024 23:1 [Internet]. 2024 Feb 10 [cited 2024 Apr 8];23(1):1–13. Available from: <https://cardiab.biomedcentral.com/articles/10.1186/s12933-024-02145-x>
- Merger SR, Kerner W, Stadler M, Zeyfang A, Jehle P, Müller-Korbsch M, et al. Prevalence and comorbidities of double diabetes. *Diabetes Res Clin Pract*. 2016 Sep 1;119(4):48–56.
- Shuster A, Patlas M, Pinthus JH, Mourtzakis M. The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. *Br J Radiol* [Internet]. 2012 Jan [cited 2024 Nov 11];85(1009):1. Available from: <https://pubmed.ncbi.nlm.nih.gov/articles/PMC3473928/>
- Madhu S, Nitin K, Sambit D, ... RNI of, 2022 undefined. ESI clinical practice guidelines for the evaluation and management of obesity in India. *Journals.lww.com* [Internet]. [cited 2024 Jun 8]; Available from: https://journals.lww.com/indjem/fulltext/2022/07000/ESI_-_Clinical_Practice_Guidelines_for_the_2.aspx
- Hagströmer M, Oja P, Sjöström M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutr* [Internet]. 2006 Sep [cited 2024 Jun 15];9(6):755–62. Available from: <https://www.cambridge.org/core/journals/public-health-nutrition/article/international-physical-activity-questionnaire-ipaq-a-study-of-concurrent-and-construct-validity/A78914A4CFE41987A40C122FDF8BE229>
- Examples of Moderate and Vigorous Physical Activity | Obesity Prevention Source | Harvard T.H. Chan School of Public Health [Internet]. [cited 2024 Jun 15]. Available from: <https://www.hsph.harvard.edu/obesity-prevention-source/moderate-and-vigorous-physical-activity/>
- Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Hills AP. Food consumption of Sri Lankan adults: an appraisal of serving characteristics. *Public Health Nutr* [Internet]. 2013 Apr [cited 2024 May 12];16(4):653–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/22784794/>
- Jayawardena R. Sri Lankan food atlas. :272.
- Arambewela Maulee, Subasinghe Chandrika, Gunathilake Sonali. Carb counter for people living with diabetes. 1st ed.
- Kim K II. Risk Stratification of Cardiovascular Disease according to Age Groups in New Prevention Guidelines: A Review. *J Lipid Atheroscler* [Internet]. 2023 May 1 [cited 2024 Jun 15];12(2):96. Available from: <https://pubmed.ncbi.nlm.nih.gov/410232216/>
- Kong M, Xu M, Zhou Y, Geng N, Lin N, Song W, et al. Assessing Visceral Obesity and Abdominal Adipose Tissue Distribution in Healthy Populations Based on Computed Tomography: A Large Multicenter Cross-Sectional Study. *Front Nutr*. 2022 Apr 25;9:81697.