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A Study of Thyroid Dysfunction in Metabolic Syndrome and its Association with Components of Metabolic Syndrome

Corresponding Author:
Dr. Kartik Ahirwar

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Dr. Kartik Ahirwar[1], Dr. Shivansh Gupta[2], Dr. Sambhav Jain[3], Dr. R. K. Jha[4]
[1-3]Postgraduate Students Department of Gen. Medicine Sri Aurobindo Medical College & PG Institute-Indore Sri Aurobindo University-Indore
[4]Prof. & HOD Department of Gen. Medicine Sri Aurobindo Medical College & PG Institute-Indore Sri Aurobindo University-Indore.

ABSTRACT

Introduction: The metabolic system disturbances show a unified metabolic control system failure which affects multiple body functions. Medical professionals now recognize metabolic syndrome as a crucial health condition because it shows how multiple factors interact through hormonal control and nutrient processing and blood vessel function to create a complex health disorder. The syndrome acts as a major health outcome predictor, which makes it essential to study all factors that might affect its onset and development. (1)

Aims: To study the thyroid dysfunction in patients with metabolic syndrome.

Material and Methods: Study design-The study involved researchers who conducted an observational study to examine patients with metabolic syndrome. The researchers conducted the study to measure how many patients had thyroid dysfunction. The researchers aimed to investigate how thyroid dysfunction related to different elements of metabolic syndrome. The study evaluated patients who met the diagnostic criteria for metabolic syndrome. The study observed participants through direct assessment methods without implementing any treatment.

Study center-The study took place at the Department of Medicine of Sri Aurobindo Institute of Medical Sciences and Post Graduate Institute which is located in Indore Madhya Pradesh. The institute served as the study centre where eligible patients were identified and evaluated. Patients attending the medicine and endocrinology outpatient department were considered for inclusion. The study included patients who were admitted to the inpatient department (IPD) as study participants. The institution served as the site for all assessment and data collection activities.

Study duration-The study was carried out over a total duration of 18 months. It commenced in June 2024 and continued until November 2025. During this period, patients meeting the inclusion criteria were enrolled in the study. Data collection and evaluation were performed throughout the defined study timeline. The entire research activity was completed within this specified duration.

Results-Correlation analysis showed no significant association of TSH and FT3 with BMI, waist circumference, SBP, DBP, FBS, TG and HDL. FT4 showed a significant positive correlation with FBS with r = 0.149 and p = 0.033. Other FT4 correlations were non-significant, including BMI r = 0.018, waist circumference r = 0.087, TG r = -0.099, and HDL r = 0.093. The majority of participants were in the 51–60 years age group, comprising 51 cases (24.9%), followed by 41–50 years with 35 cases (17.1%) and 31–40 years with 29 cases (14.1%). The least represented age group was ≤20

years, with 3 cases (1.5%). The total study population included 205 participants (100.0%).

Conclusion-The present study concluded that thyroid dysfunction was common among patients with metabolic syndrome, with 69 out of 205 participants (33.7%) showing some form of thyroid abnormality, while 136 participants (66.3%) were euthyroid. The most frequent thyroid dysfunction was subclinical hypothyroidism, observed in 42 cases (20.5%), followed by overt hypothyroidism in 13 cases (6.3%), subclinical hyperthyroidism in 10 cases (4.9%), and overt hyperthyroidism in 4 cases (2.0%). This pattern indicates that hypothyroid states were more common than hyperthyroid states in patients with metabolic syndrome, with a combined hypothyroid prevalence of 26.8% compared with hyperthyroid states in 6.9%. The study population had an average age of 51.75 which saw most participants belonging to the 51–60 years age group.

Keywords: Metabolic Syndrome, Thyroid Dysfunction, Subclinical Hypothyroidism, Thyroid-Stimulating Hormone (TSH), Thyroid Function Tests.

INTRODUCTION

Metabolic syndrome represents a set of interconnected metabolic disorders which together create physiological imbalance and increase the risk of developing chronic health issues. The condition shows multiple cardiometabolic risk factors which all stem from the same metabolic and hormonal control problems. The metabolic system disturbances show a unified metabolic control system failure which affects multiple body functions. Medical professionals now recognize metabolic syndrome as a crucial health condition because it shows how multiple factors interact through hormonal control and nutrient processing and blood vessel function to create a complex health disorder. The syndrome acts as a major health outcome predictor, which makes it essential to study all factors that might affect its onset and development. (1)

Thyroid function serves as the primary control mechanism which manages all metabolic activities that sustain the body's internal stability. Thyroid hormones control multiple biochemical processes that determine how the body expends energy and uses different substances and produces heat and performs cellular respiration. These hormones control mitochondrial functions through both genomic and non-genomic mechanisms while they determine which metabolic processes will proceed through anabolic or catabolic pathways. The metabolic state of a person will become unbalanced whenever their thyroid function undergoes any modification because this condition affects the body's entire metabolic system. The treatment of thyroid dysfunction has become important for understanding metabolic disturbances because metabolic syndrome itself represents a disorder that results from disrupted metabolic control. Researchers have documented thyroid abnormalities as elements that influence metabolic processes because they discovered that endocrine control plays an essential role in preserving cardiometabolic health. (2)

Metabolic syndrome is typically understood as three cardiovascular risk factors which together increase heart disease risk. The thyroid hormones show multiple pathways through which they impact cardiovascular system functions. The hormones control heart muscle contraction to determine blood flow through blood vessels and they regulate how the body processes fats. Through transcriptional regulation triiodothyronine affects genes which control adipogenesis and glucose oxidation and thermogenesis to establish a connection between hormonal systems and heart metabolic processes. The body uses thyroid hormones to create conditions which lead to both vascular damage and metabolic health problems. The mechanisms that scientists have discovered create a theoretical structure which supports research into how thyroid function affects metabolic syndrome. (3)

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The definition of metabolic syndrome requires the presence of central fatness together with atherogenic dyslipidemia and high blood pressure and glucose metabolism disturbances and their associated pro-inflammatory and prothrombotic conditions. The body uses thyroid hormones to control three processes which include food consumption and body heat production and the energy used while resting. The hormones control transcription factors which mediate the development

of adipose tissue and the process of metabolic oxidation to help sustain metabolic balance. The body develops metabolic disorders when thyroid function begins to operate outside its normal limits because this situation disrupts metabolic control mechanisms. The pathways of thyroid dysfunction and metabolic syndrome show a clear connection which establishes a solid basis for research into their metabolic relationship with thyroid dysfunction. (5)

Background

The metabolic syndrome which requires the presence of multiple metabolic disorders to diagnose. The condition which consists of multiple interrelated risk factors manifests through disruptions to the body's energy control and fat tissue operations and hormonal communication systems. The syndrome proves to be a critical health issue in contemporary medicine because it causes widespread metabolic disturbances which affect various body systems. The body requires fundamental knowledge about its metabolic processes to comprehend how metabolic disorders progress and interact throughout the body. (6,7)

Thyroid Physiology and Thyroid Dysfunction

The endocrine system controls thyroid physiology to establish metabolic balance and body temperature control and proper cell operation. The thyroid gland produces hormones that affect multiple body systems because these hormones control oxygen intake and energy creation and chemical processes. The thyroid gland acts as a vital endocrine organ because its hormones support proper growth and neurological development and metabolic equilibrium. Proper thyroid function requires a complex system that controls hormone creation and uses feedback controls and activates hormones throughout the body. Any disruption which occurs during this process will lead to thyroid dysfunction which extends its effects throughout the body system (8).

Thyroid Hormone Synthesis

Thyroid hormone synthesis is a multistep biochemical process that occurs within the follicular cells and depends heavily on iodine availability. The process begins with the active transport of iodide from the bloodstream into thyroid cells via specialized membrane transporters. Iodide enters the cell where it undergoes oxidation to become part of tyrosine residues in thyroglobulin which creates iodinated intermediates that will later combine to form thyroxine and triiodothyronine. The pathway maintains strict control which produces hormones at a stable rate needed for metabolic balance to be achieved (9).

Need for Integrated Metabolic Assessment

The endocrine system functions together with the metabolic system to create complex interactions which require doctors to evaluate patients through an integrated assessment method. The metabolic syndrome condition extends beyond single biochemical abnormalities because it encompasses multiple interconnected physical disorders that affect hormonal transmission and inflammatory systems and blood vessel control. The evaluation of thyroid function through metabolic assessments provides a comprehensive view of patient health. (10)

MATERIAL AND METHODS

1. Study design

The study involved researchers who conducted an observational study to examine patients with metabolic syndrome. The researchers conducted the study to measure how many patients had thyroid dysfunction. The researchers aimed to investigate how thyroid dysfunction related to different elements of metabolic syndrome. The study evaluated patients who met the diagnostic criteria for metabolic syndrome. The study observed participants through direct assessment methods without implementing any treatment.

2. Study setting

The study took place at the Department of Medicine of Sri Aurobindo Institute of Medical Sciences and Post Graduate Institute which is located in Indore Madhya Pradesh. The institute served as the study centre where eligible patients were identified and evaluated. Patients attending the medicine and endocrinology outpatient department were considered for inclusion. The study included patients who were admitted to the inpatient department (IPD) as study participants. The institution served as the site for all assessment and data collection activities.

3. Study duration

The study was carried out over a total duration of 18 months. It commenced in June 2024 and continued until November 2025. During this period, patients meeting the inclusion criteria were enrolled in the study. Data collection and evaluation were performed throughout the defined study timeline. The entire research activity was completed within this specified duration.

4. Participants – inclusion and exclusion criteria

Inclusion criteria

- Patients aged more than 18 years, who will fulfill the criteria for metabolic syndrome according to the modified Asian NCEP-ATP III panel criteria visiting the Outpatient and inpatient Department of General Medicine / Endocinology will be included in this study.

Exclusion criteria
- Patients with Pre-existing thyroid dysfunction
- Patients receiving medication that may alter thyroid functions.
- Critically ill patient.
- Pregnant women.

5. Study sampling
Patients who were diagnosed with metabolic syndrome and fulfilled the inclusion and exclusion criteria while attending the medicine/endocrinology outpatient department and IPD during the study period were included in the study.

6. Study sample size
The sample size was calculated using the formula $n = Z^2 1- \alpha/2P(1-P) / l^2$. In this formula, n represented the sample size, Z was taken as 1.96 at a 95% level of significance, P denoted the expected prevalence of thyroid dysfunction in metabolic syndrome, and l indicated the relative error, which was considered as 20% of P. Based on this calculation, the required sample size was determined to be 205. Therefore, a total of 205 patients who satisfied the inclusion criteria were included in the study. All participants were enrolled only after obtaining voluntary consent.

7. Study groups
All participants were classified into groups according to their thyroid profile. Euthyroid participants had TSH, free T3, and free T4 within the normal range. Overt hypothyroidism was defined as TSH >10 mIU/L with free T3 and free T4 below the reference range. Subclinical hypothyroidism was defined as TSH 5–10 mIU/L with free T3 and free T4 within the reference range. Subclinical hyperthyroidism was defined as TSH <0.25 mIU/L with free T3 and free T4 within the reference range. Overt hyperthyroidism was defined as suppressed TSH with elevated T3 and T4 levels.

8. Study parameters
- Metabolic syndrome was diagnosed using the modified Asian NCEP-ATP III panel criteria.
- The presence of any three of the following five factors was required for diagnosis:
- Central obesity (male >102 cm waist circumference, female >88 cm waist circumference)
- Hypertriglyceridemia (triglycerides >150 mg/dl)
- Low HDL cholesterol (≤40 mg/dl for men and ≤50 mg/dl for women)
- Elevated blood pressure (systolic ≥130 mmHg and/or diastolic ≥85 mmHg or current use of antihypertensive drugs)
- Impaired fasting glucose (≥100 mg/dl)
- Patients with metabolic syndrome were considered to have thyroid dysfunction if their thyroid hormone levels fell outside the normal reference range:
- Free T3 (2.0–4.4 pg/ml)
- Free T4 (1.0–1.7 ng/dl)
- TSH (0.27–4.20 mIU/L)

9. Study procedure
Written informed consent was taken from all participants before their inclusion in the study. Each participant was enrolled only after providing voluntary consent. A detailed medical and personal history was obtained from every patient. Demographic details were recorded for all participants. Clinical details such as height and weight were measured. Anthropometric measurement including waist circumference was also recorded. Blood pressure was measured in each participant. All the obtained information was entered into a pre-structured proforma.

Following the detailed history, a thorough clinical examination was conducted for every patient. Blood samples were drawn only after eight hours of fasting. The collected blood samples were used for fasting blood sugar, lipid profile, and thyroid function tests including FT3, FT4, and TSH. All investigations were performed in all participants. Ultrasonography of the neck was also performed in all participants as part of the study procedure.

RESULTS
Age-wise Distribution of Study Participants

The majority of participants were in the 51–60 years age group, comprising 51 cases (24.9%), followed by 41–50 years with 35 cases (17.1%) and 31–40 years with 29 cases (14.1%). The least represented age group was ≤20 years, with 3 cases (1.5%). The total study population included 205 participants (100.0%).

Table 1: Age-wise Distribution of Study Participants

Age	Frequency	Percent
≤ 20	3	1.5
21 - 30	27	13.2
31 - 40	29	14.1
41 - 50	35	17.1
51 - 60	51	24.9
61 - 70	23	11.2
71 - 80	26	12.7
81 - 90	11	5.4
Total	205	100.0

Table 2: Descriptive Statistics of Clinical, Anthropometric, Biochemical and Thyroid Parameters

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	205	18	90	51.75	17.634
Height	205	155	186	167.56	5.051
Weight	205	58	100	75.85	8.205
BMI	205	21.6	148.0	27.520	8.7884
Waist circumferance	205	78	136	96.08	8.979
SBP	205	100	180	134.95	12.860
DBP	205	60	92	80.60	5.233
FBS	205	76	310	122.23	32.195
TG	205	34	525	145.93	92.519
HDL	205	5.00	110.00	37.8916	15.69089
TSH	205	0.005	72.090	4.44852	8.130776
FT3	205	0.140	13.580	2.63686	1.466612
FT4	205	0.092	6.990	1.39189	0.658696
Metabolic syndrome component	205	3	5	3.32	0.537

Distribution According to USG Neck Findings

Among 205 participants, USG neck was not performed or not available in 204 cases (99.5%), while normal USG neck findings were reported in 1 case (0.5%). The total study population included 205 cases (100.0%), indicating that almost all participants had no recorded USG neck findings.

Table 3: Distribution According to Thyroid Status

Thyroid Status	Frequency	Percent
Euthyroid	136	66.3
Overt Hyperthyroidism	4	2.0
Overt Hypothyroidism	13	6.3
Subclinical Hyperthyroidism	10	4.9
Subclinical Hypothyroidism	42	20.5
Total	205	100.0

Correlation of Thyroid Hormones with Components of Metabolic Syndrome

Correlation analysis showed no significant association of TSH and FT3 with BMI, waist circumference, SBP, DBP, FBS, TG and HDL. FT4 showed a significant positive correlation with FBS with $r = 0.149$ and $p = 0.033$. Other FT4 correlations were non-significant, including BMI $r = 0.018$, waist circumference $r = 0.087$, TG $r = -0.099$, and HDL $r = 0.093$.

Table 4: Correlation of Thyroid Hormones with Components of Metabolic Syndrome

Variables	TSH (r, p)	FT3 (r, p)	FT4 (r, p)
BMI	-0.051 (0.467)	-0.032 (0.646)	0.018 (0.800)
Waist Circumference	-0.063 (0.372)	-0.003 (0.962)	0.087 (0.215)
SBP	0.003 (0.970)	0.096 (0.172)	0.057 (0.414)
DBP	-0.032 (0.653)	0.005 (0.948)	0.000 (1.000)
FBS	-0.112 (0.111)	-0.021 (0.765)	*0.149 (0.033) **
TG	0.021 (0.763)	-0.136 (0.051)	-0.099 (0.159)
HDL	-0.128 (0.068)	0.020 (0.775)	0.093 (0.183)

Correlation Between Thyroid Hormones

Correlation between thyroid hormones showed a statistically significant negative correlation between TSH and FT4, with $r = -0.214$ and $p = 0.002$. A statistically significant positive correlation was observed between FT3 and FT4, with $r = 0.330$ and $p < 0.001$. These results indicate significant interrelationship among thyroid hormone parameters.

DISCUSSION

The aim of the present study was to evaluate the pattern of thyroid dysfunction in patients with metabolic syndrome and to assess its association with individual components of metabolic syndrome, including BMI, waist circumference, systolic blood pressure, diastolic blood pressure, fasting blood sugar, triglycerides and HDL cholesterol. The study was also intended to determine the distribution of thyroid status among patients with metabolic syndrome by categorizing participants into euthyroid, subclinical hypothyroidism, overt hypothyroidism, subclinical hyperthyroidism and overt hyperthyroidism groups. The significance of this study lies in the close metabolic relationship between thyroid dysfunction and metabolic syndrome, as thyroid hormones have an important role in regulating basal metabolic rate, lipid metabolism, glucose homeostasis, body weight and cardiovascular function. Metabolic syndrome itself is a major risk factor for type 2 diabetes mellitus, hypertension, dyslipidemia and cardiovascular disease. When thyroid dysfunction coexists with metabolic syndrome, it may further worsen metabolic abnormalities and increase long-term morbidity. In the present study, thyroid dysfunction was observed in 33.7% of participants, with subclinical hypothyroidism being the most common abnormality at 20.5%, highlighting the importance of detecting clinically silent thyroid dysfunction. The study also demonstrated significant association of metabolic syndrome component burden with waist circumference, systolic blood pressure and HDL, indicating their role as markers of metabolic severity. Therefore, the study is significant because it supports the need for routine thyroid function assessment in patients with metabolic syndrome, enabling early diagnosis, timely intervention and better prevention of cardiometabolic complications.

In the present study, females constituted a higher proportion of the study population, with 117 females (57.1%), while males accounted for 88 cases (42.9%) among the total 205 participants. This female predominance may be related to a higher frequency of thyroid dysfunction among women and greater vulnerability to metabolic changes associated with obesity, hormonal variation, postmenopausal status and altered lipid metabolism. The association between age group and sex distribution was not statistically significant, with $p = 0.077$, indicating that although females were numerically more common, the sex distribution across different age groups did not show a statistically meaningful difference. In the largest age group of 51–60 years, females and males were almost equally represented, with 26 females and 25 males. Deshmukh et al. (2018) also reported that thyroid dysfunction was more prevalent in females among patients with metabolic syndrome [11]. Elebrashy et al. (2016) documented a high prevalence of thyroid dysfunction, particularly hypothyroidism, among female patients with type 2 diabetes mellitus [12]. Thus, the present female predominance is supported by previous studies showing increased thyroid and metabolic vulnerability among women, although screening remains important in both sexes. The mean metabolic syndrome component score in the present study was 3.32 ± 0.537, with values ranging from 3 to 5, confirming that all participants fulfilled diagnostic criteria for metabolic syndrome. Most participants had 3 components, comprising 146 cases (71.2%), followed by 4 components in 52 cases (25.4%) and 5 components in 7 cases (3.4%). This distribution indicates that the majority had minimum diagnostic clustering, while fewer participants had more severe metabolic burden. Metabolic syndrome component score showed significant positive correlation with SBP $r = 0.217$, $p = 0.002$ and waist circumference $r = 0.161$, $p = 0.021$, and significant negative correlation with HDL $r = -0.267$, $p < 0.001$. Deshmukh et al. (2018) reported that thyroid dysfunction in metabolic syndrome was associated with increased waist circumference, insulin resistance and dyslipidemia [13]. Gupta et al. (2021) reported thyroid dysfunction in 28.5% and association with diabetes mellitus and hypertriglyceridemia [14]. In the present study, thyroid hormones did not significantly vary with component score, but waist circumference, SBP and HDL were strongly related to increasing metabolic burden. This highlights central obesity, systolic hypertension and low HDL as key severity markers.

In the present study, USG neck findings were not available or not performed in 204 cases (99.5%), while only 1 case (0.5%) had normal USG neck findings. Therefore, meaningful interpretation regarding thyroid morphology, thyroid nodules, gland size, echotexture or structural thyroid disease could not be made from the available data. The study therefore primarily assessed biochemical thyroid dysfunction through thyroid status, TSH, FT3 and FT4 rather than structural thyroid

abnormalities. Kir et al. (2018) examined the relationship between metabolic syndrome and nodular thyroid disease and reported a higher prevalence of thyroid nodules among individuals with metabolic syndrome compared with the general population [15]. Kir et al. also observed that obesity, insulin resistance and dyslipidemia were significantly associated with nodular thyroid disease [15]. Since the present study did not include adequate USG neck data, direct comparison with structural thyroid findings reported by Kir et al. remains limited. However, the high thyroid dysfunction rate of 33.7% in the present study suggests that thyroid evaluation remains clinically relevant in metabolic syndrome. Future studies may include routine thyroid ultrasound to assess both functional and morphological thyroid abnormalities.

CONCLUSION

The present study concluded that thyroid dysfunction was common among patients with metabolic syndrome, with 69 out of 205 participants (33.7%) showing some form of thyroid abnormality, while 136 participants (66.3%) were euthyroid. The most frequent thyroid dysfunction was subclinical hypothyroidism, observed in 42 cases (20.5%), followed by overt hypothyroidism in 13 cases (6.3%), subclinical hyperthyroidism in 10 cases (4.9%), and overt hyperthyroidism in 4 cases (2.0%). This pattern indicates that hypothyroid states were more common than hyperthyroid states in patients with metabolic syndrome, with a combined hypothyroid prevalence of 26.8% compared with hyperthyroid states in 6.9%. The study population had an average age of 51.75 which saw most participants belonging to the 51–60 years age group.

The study found that females represented 57.1% of participants while males made up 42.9% but the researchers found no statistical link between age group and sex distribution ($p = 0.077$). The typical metabolic profile of the study group showed mean BMI values of 27.520 ± 8.7884 kg/m² and waist circumference values of 96.08 ± 8.979 cm and systolic blood pressure values of 134.95 ± 12.860 mmHg and fasting blood sugar values of 122.23 ± 32.195 mg/dL and triglyceride levels of 145.93 ± 92.519 mg/dL and HDL levels of 37.8916 ± 15.69089 mg/dL. Most participants had 3 metabolic syndrome components (71.2%), followed by 4 components (25.4%) and 5 components (3.4%), indicating that the majority fulfilled the minimum diagnostic clustering of metabolic syndrome. Correlation analysis showed that TSH and FT3 did not have statistically significant correlation with BMI, waist circumference, SBP, DBP, FBS, TG or HDL, suggesting that thyroid dysfunction may coexist with metabolic syndrome without showing a direct linear association with each individual component.

However, FT4 showed a statistically significant positive correlation with fasting blood sugar ($r = 0.149$, $p = 0.033$), indicating a weak but significant relationship between thyroid hormone activity and glycemic status. Interrelationship between thyroid hormones was biologically consistent, as TSH showed a significant negative correlation with FT4 ($r = -0.214$, $p = 0.002$), while FT3 showed a significant positive correlation with FT4 ($r = 0.330$, $p < 0.001$). The study also demonstrated that metabolic syndrome component burden was significantly associated with central obesity, systolic hypertension and low HDL. Metabolic syndrome component score showed significant positive correlation with systolic blood pressure ($r = 0.217$, $p = 0.002$) and waist circumference ($r = 0.161$, $p = 0.021$), and significant negative correlation with HDL ($r = -0.267$, $p < 0.001$). Across increasing component groups, waist circumference rose significantly from 95.28 ± 8.83 cm to 102.00 ± 6.21 cm ($p = 0.041$), systolic blood pressure rose from 133.35 ± 13.26 mmHg to 145.14 ± 15.48 mmHg ($p = 0.007$), and HDL decreased significantly from 40.72 ± 16.77 mg/dL to 31.57 ± 10.22 mg/dL ($p < 0.001$).

The research results show that waist circumference and systolic blood pressure together with HDL levels worked as the principal factors which determined how metabolic syndrome developed in severity. The study found that thyroid hormone levels remained constant across the three metabolicsyndrome groups which had different numbers of components yet the study found that thyroid screening should occur for metabolic syndrome patients because of the high rates of thyroid dysfunction which primarily involved subclinical hypothyroidism. The study therefore shows that metabolic syndrome evaluation needs to occur through two assessment methods which include both its cardiometabolic characteristics and its association with thyroid dysfunction. Early identification of thyroid abnormalities in metabolic syndrome patients allows healthcare providers to manage the condition while preventing future health problems and reducing the risk of cardiovascular and metabolic complications which develop over time.

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