“RELATIONSHIP BETWEEN SERUM MAGNESIUM LEVELS AND INSULIN RESISTANCE IN OVERWEIGHT CHILDREN”

BY

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Dissertation submitted to

B.L.D.E (DEEMED TO BE UNIVERSITY) VIJAYAPURA KARNATAKA

In partial fulfilment of the requirements for the degree of

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I hereby declare that this dissertation/thesis entitled "**RELATIONSHIP BETWEEN SERUM MAGNESIUM LEVELS AND INSULIN RESISTANCE IN OVERWEIGHT CHILDREN**" has been prepared by me under the supervision and guidance of **Dr S.S.KALYANSHETTAR,** M.D, Professor, Department of Pediatrics. This is being submitted to BLDE (Deemed to be University) Shri B.M. Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka in partial fulfilment of the requirement for award of master's degree in Pediatrics. This work has not been submitted to any University by me for award of any degree.

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GLOSSARY OF ABBREVIATIONS

BMI	Body Mass Index
IAP	Indian academy of Paediatrics
WHO	World Health Organisation
CDC	Centre for Disease Control and Prevention
NCD	Non Communicable Diseases
TRPM	Transient Receptor Potential Melastain
CNNM	Cyclin & CBS domain Divalent metal Cation transport mediator
POMC	Pro Opio Melano Cortins
CART	Cocaine- and Amphetamine- related transcript
AgRP	Agouti-related peptide
MC4	Melanocortin 4
NASH	Non Alcoholic Steato Hepatitis
NPY	Neuropeptide Y
HDL	High Density Lipoproteins
LDL	Low Density Lipoproteins
VLDL	Very Low Density Lipoproteins
IR	Insulin Resistance
SERPINS	Serine Protease Inhibitors
GLUT 4	Glucose Transporter 4
PPAR γ	Peroxisomal Proliferator-Activated Receptor- γ
SGA	Small for Gestational Age
LCAT	Lecithin cholesterol acyl tranferase

11βHSD1	11βhydroxysteroid dehydrogenase type 1
IGF-1	Insulin like Growth Factor-1
SHBG	Sex Hormone Binding Globulin
CRP	C Reactive Protein
DM	Diabetes Mellitus
IGFBPs	Insulin like Growth factor Binding Proteins
TNF-α	Tumor Necrosis Factor-α
IL-6	Interleukin-6
OGTT	Oral Glucose Tolerance Tests
FSIVGTT	Frequently Sampled IV Glucose Tolerance Test
HOMA-IR	Homeostasis model assessment-insulin resistance index
QUICKI	Quantitative Insulin Check Index
SD	Standard Deviation

ABSTRACT

Background: This cross-sectional case-control study aimed to explore the relationship between serum magnesium levels and insulin resistance in children with overweight or obesity.

Methodology: At Shri B M Patil Medical College Hospital, this 1.5-year cross-sectional case-control investigation investigated the association among levels of magnesium in the blood and insulin resistance in children aged 5 to 16. Cases met the 2015 revised IAP growth charts for overweight or obesity, in comparison to age-matched healthy controls. Exclusions included secondary causes of obesity and medical complications affecting magnesium. Assessments involved clinical history, examination, and fasting blood tests for insulin resistance indices. The study aimed for a total sample size of 110 participants, utilizing G*Power software.

Results: Overweight children exhibited significantly lower mean serum magnesium levels compared to controls (1.03 mEq/l vs. 1.85 mEq/l, $p < 0.001$). Anthropometric measures, including BMI and percentage body fat, were significantly higher in cases. Metabolic markers, such as fasting insulin, HOMA, and lipid profiles, also demonstrated substantial differences. Systolic blood pressure, while not significantly different, displayed a trend towards elevation in overweight children.

Conclusion: This finding underscores the potential relevance of magnesium in the context of childhood obesity and its metabolic consequences.

INTRODUCTION

The global prevalence of childhood obesity has increased by a factor of ten: the number of obese boys and girls increased from 5 and 6 million in 1975 to 50 and 74 million in 2016.[1] Obesity is projected to affect 25% of children under the age of 16 by the conclusion of 2050, assuming trends that have persisted since 2000.[2] Hence, obesity constitutes a worldwide public health concern that directly affects the well-being of children and engenders a myriad of adverse immediate and prolonged consequences.[3]

Childhood morbidities due to obesity include sleep apnea, gastrointestinal, musculoskeletal, and orthopaedic complications; it also accelerates the onset of type 2 diabetes and cardiovascular disease, and it is a direct cause of the comorbidities of these two noncommunicable diseases (NCDs).[4] As a result, there is a pressing need for health systems to take immediate action to address the issue.[3] Without a doubt, obesity poses a significant risk for NCDs, which can result in lifelong morbidity. On the other hand, the development of obesity is a multifaceted, intricate process that begins before birth. Unfavourable foetal circumstances are linked to the development of noncommunicable diseases (NCDs) in later life, according to the Developmental Origins of Health and Disease (DoHAD) theory.[5,6]

The human body's fourth most abundant cation is magnesium (Mg2+), which is also the second most abundant intracellular cation. Approximately 60% of the body's Mg2+ is present in the bones, 40% in soft tissues, and less than 1% in the blood. It functions as a structural or catalytic component of the enzymes as well as a cofactor on the substrates in hundreds of enzymatic processes. Mg2+ bioactive activity can be exemplified by reactions utilising the compound Mg-ATP, a crucial cofactor for kinases.

This is why many of the enzymes involved in the metabolism of carbohydrates and energy include Mg2+ as a rate-limiting component. In addition, Mg2+ is required for macromolecule synthesis during the intermediate metabolism..[7] Neurotransmitter release, appropriate brain function, and muscular contraction and relaxation are other essential Mg2+-dependent processes.[8]

Transporters and membrane channels collaborate at the cellular level to maintain Mg2+ homeostasis. Certain proteins are ubiquitously expressed, including transient receptor potential melastatin (TRPM) 7, Mg2+ transporter 1 (MagT1), and solute carrier family 41 member 1 (SLC41A1). Certain proteins are specific to particular tissues, such as CNNM4 and (CNNM2), which are both found in the colon. Additionally, TRPM6 is expressed in both the kidney and the colon.[9]

It has been found that there is a considerable correlation between insulin action and magnesium.[8,9] Adults with reduced insulin production, poor glucose tolerance, and low blood and intracellular magnesium concentrations are linked to insulin resistance.[10–12] Large epidemiologic studies on adults also suggest that a lower blood and dietary magnesium level is linked to a higher risk of type 2 diabetes.[13,14] Numerous studies have highlighted a significant relationship between serum magnesium levels and markers of insulin resistance and metabolic syndrome. Despite extensive Indian research indicating a connection between low serum magnesium levels and obesity, there is a scarcity of information regarding this association in the tier-2 cities of North Karnataka region. To address this gap, the aim is to compare magnesium levels between overweight and normal-weight children. The presence of an extensive link among deficient levels of magnesium and resistance to insulin within a demographic undergoing an increase in overweight individuals may prompt an inquiry into the potential of magnesium supplementation in overweight children to alleviate insulin resistance.

AIM AND OBJECTIVES

Aim:

To investigate the correlation between insulin resistance and serum magnesium levels in children aged 5 to 16 years who are overweight.

Objectives:

1. To determine whether overweight and obese adolescents have lower serum magnesium levels than controls of the matched age and gender.
2. To determine whether insulin resistance is correlated with reduced serum magnesium levels in obese and overweight children aged 5 to 16 years.

REVIEW OF LITERATURE

Childhood Obesity:

Childhood obesity is one of the greatest challenges to health care in the twenty-first century. The problem is pervasive and worsening over time in a number of middle-income and low-income countries, particularly in urban centres. The rate of prevalence increase is cause for concern. Obesity in childhood substantially elevates the likelihood of an individual developing various ailments, such as coronary artery disease, insulin resistance, musculoskeletal disorders, and diabetes mellitus.

Epidemiology - Childhood Obesity:

In 2018, household survey data revealed that forty million children globally, or 5.9% of the total child population, were overweight. This is a 33% increase in the burden compared to the predicted 30 million under-five overweight people in 2000. The incidence varies significantly by area, ranging from 2.8% in West and Central Africa to 14.9% in Eastern Europe and Central Asia.[15]

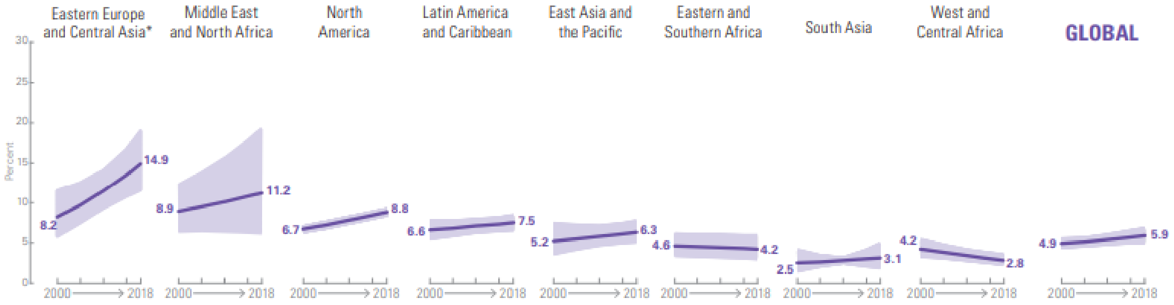


Fig 1: Overweight in under 5 children in UNICEF region

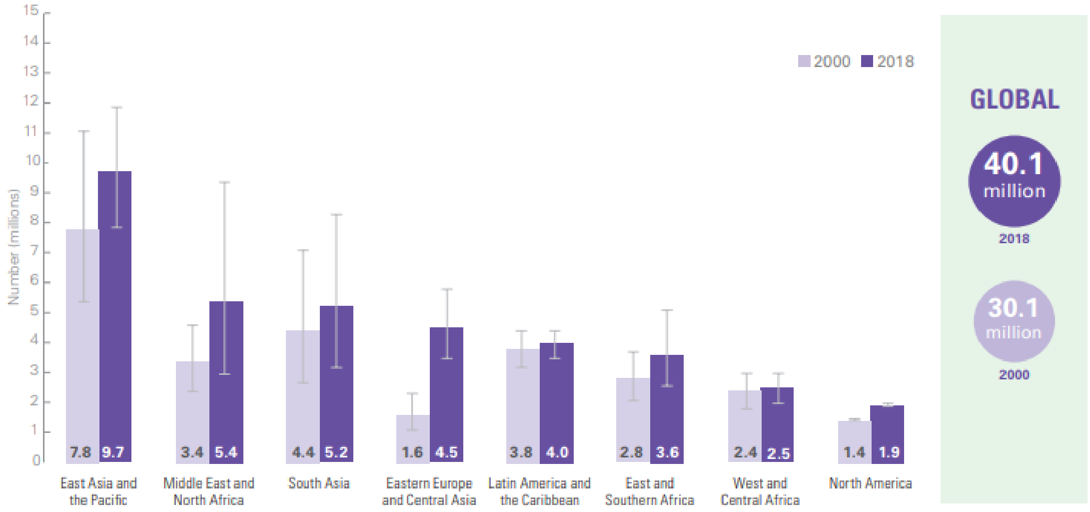


Fig 2: Comparison of prevalence of overweight among under 5 children in 2000 and 2018

Numerous surveys are used to gather data on overweight children between the ages of 5 and 19, each with a different technique and age group breakdown (e.g., home or school-based surveys). Overweight in this age range is becoming more common worldwide. Around 338 million children between the ages of five and nineteen were overweight globally in 2016, accounting for roughly one in five school-age children and adolescents (18.4%).[16,17]

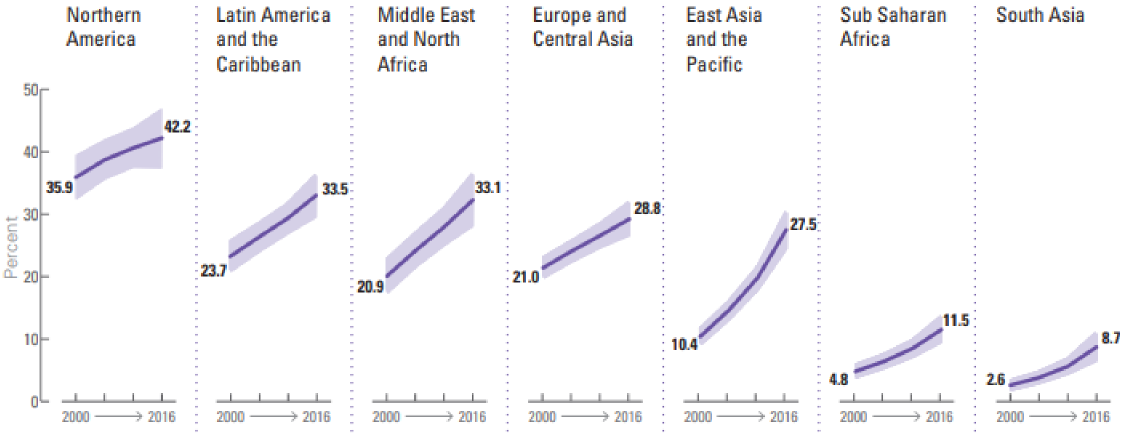


Fig 3: Prevalence of Overweight among 5 to 9 years old in UNICEF regions

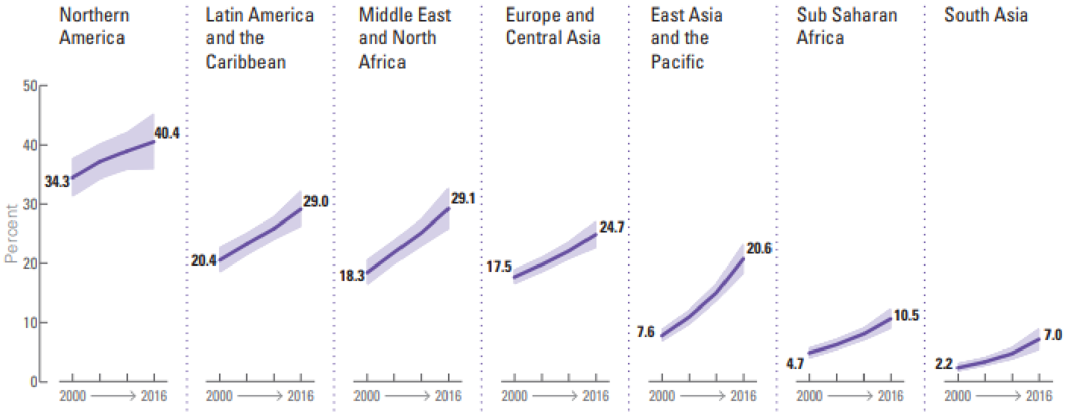


Fig 4: Prevalence of overweight among 10 to 19 years old in UNICEF regions

In the past, overweight has mostly been an issue in higher-income nations, primarily affecting the urban and middle-class populations in these nations. The burden of overweight has disproportionately affected lower socioeconomic groups in established overweight epidemics. According to new data, these trends are shifting, with overweight becoming more common in low- and middle-income nations as well as among impoverished children living in both urban and rural areas.[18] More than 75% of overweight children live in middle-income nations: 38% of overweight children reside in lower middle-income countries, and 39% live in higher middle-income countries. Lower middle-income nations have had the largest growth in the number of overweight children under five since 2000 (from 9.8 million in 2000 to 12.5 million in 2017).[19]

A multitude of factors have played a role in the worldwide increase in adolescent obesity and overweight.:[20]

1. There is a worldwide dietary trend in raised consumption of energy-dense foods which are deficient with essential micronutrients & vitamins, while being rich in fat and sugar.
2. A decline in physical activity due to individuals adopting sedentary lifestyles and devoting more time to screen time, computer usage, and video game consumption rather than venturing outdoors; and

3. An upward trend in urbanisation and transportation transformations.

Definition:

Obesity is defined as "an excessive or abnormal building up of fat in adipose tissue to the point that health may be impaired" by the World Health Organisation (WHO).[21]

BMI, or body mass index, is the recommended method for identifying overweight or obese adolescents. It is calculated by dividing weight in kilograms by height in meters squared. Additional methodologies for quantifying obesity include skin-fold dimension, electrical impedance, densitometry, Computed Tomography, and magnetic resonance imaging.

BMI:[22]

$$\text{BMI} = \text{Weight (kg)} / [\text{Height (m)}]^2$$

Classification of BMI:

The age and gender-specific BMI charts developed by CDC are utilised to detect obesity in children.[23]

Table 1: BMI cut off given by CDC

5th to 84th percentile	Normal
85th to 95th percentile	Overweight
>95th percentile	Obesity

By World Health Organisation (WHO) standards, obesity is defined as having a BMI of 30 kg/m2 or higher at the age of 19, which is equivalent to a +2 standard deviation; overweight is defined as having a BMI of 25 kg/m2 or higher at the same age.[24]

Children between the ages of 5 to 18 have been categorised by the Indian Academy of Paediatrics (IAP) according to their BMI.

Table 2: IAP criteria

23 to 27 adult equivalent centiles	Overweight
>27 adult equivalent centiles	Obesity

Pathogenesis:

Body weight is regulated by the energy balance equation, which is composed of energy expenditure and intake.[26]

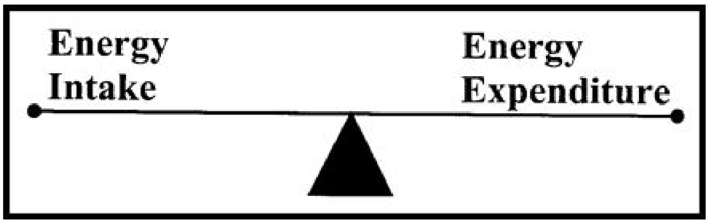


Fig 5: Energy Balance Equation

An imbalance in the amount of energy consumed and expended will directly affect body weight. Obesity can result from a combination of genetic, environmental, endocrine, neurological, and behavioural variables that impact the energy balance equation.[26]

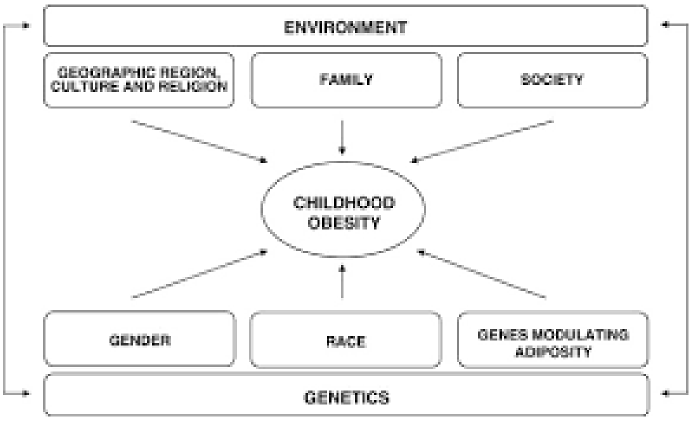


Fig 6: Factors affecting Childhood obesity

Neuronal and Endocrine factors:

The set point mechanism is a physiological phenomenon that operates on the basis of adipostat receptor in the brain's hypothalamus and a sensing system in adipocytes. In reaction to the exhaustion of fat stores, adipocytes transmit signals to the adipostat receptor, which subsequently inhibits energy expenditure and increases hunger; conversely, adipocytes suppress energy expenditure.[27.28]

Table 3: Neuronal and Endocrine factors and obesity

	Appetite	**Satiety**
Gastrointestinal hormones	Ghrelin	Cholecystokinin, glucagon like peptide 1, peptide YY
Adipose tissue		Leptin
Neuropeptides	Neuropeptide Y(NPY), agouti gene related peptide (AgRP) and orexin	Pro opio melanocortin (POMC), cocaine and amphetamine related transcript (CART)

Role of Genes:

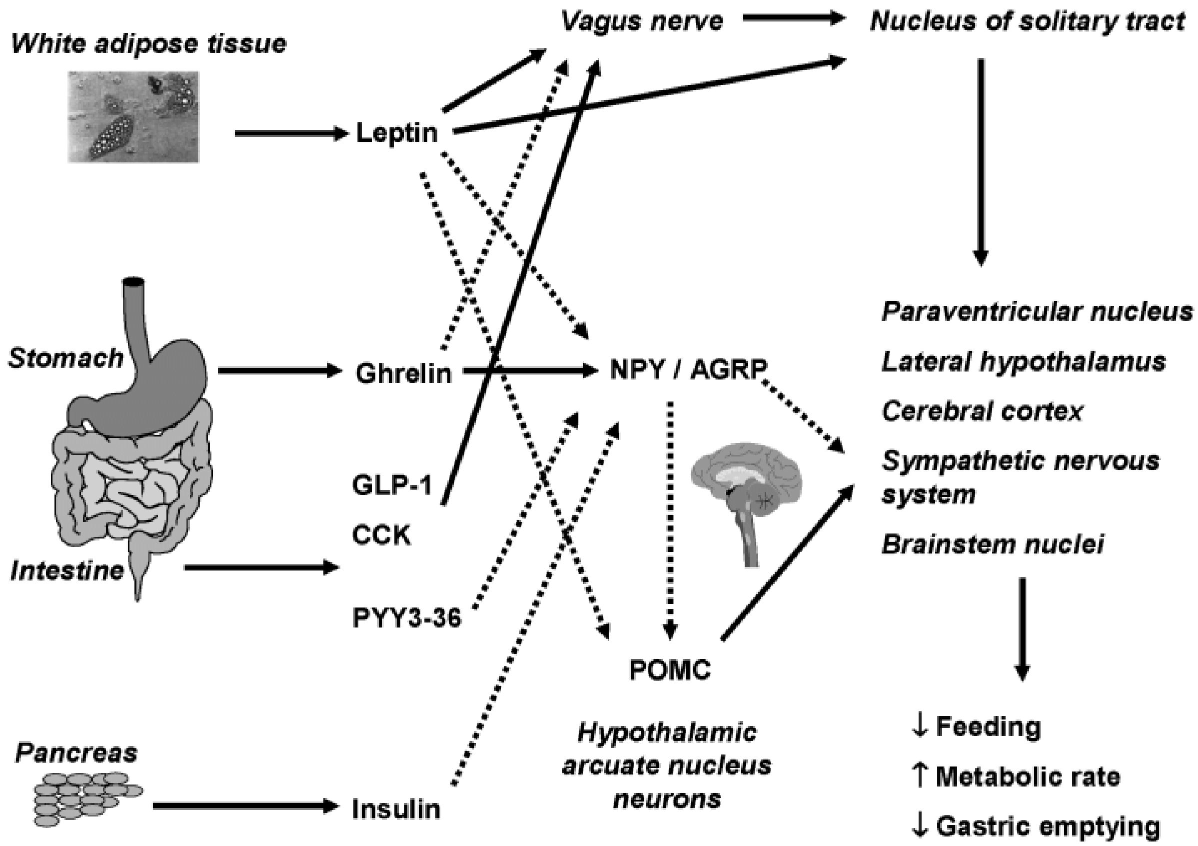


Fig 7: Appetite regulation

Monogenetic variations of obesity arise from genetic mutations in the protein codes for neuropeptides, hormones secreted by adipose tissue. [29]

Role of environment:

Probably the biggest factor contributing to the obesity epidemic and rising rates of overweight is the way that environmental changes are creating fat.[30]

Extreme shifts in lifestyle and behaviour over the past few decades in different parts of the world have resulted in an increase in sedentary activities and hours of inactivity because most people now spend most of their time indoors watching television, playing video games, using computers, and using cell phones, instead of going outside and engaging in physical activity. The obesity rate among adolescents is 8.3 times higher when they watch media for over five hours per day compared to when they watch television for no more than two hours per day. This indicates that adolescent obesity is directly related to television viewing.

Additionally, children's modes of mobility have changed, with the majority choosing to use lifts instead of stairs and cars for short trips rather than walking.

Due to urbanisation, the majority of households now have two working parents, and as a result, they are less likely to have the time to monitor their children's dietary and physical habits.[30,31]

Merely 25–30% of students actively participate in physical activities, indicating a decline in physical activity in schools.[32,33] Globally, there has been much speculation that a consistent drop-in physical activity across all age groups is a major factor in the growing prevalence of obesity.

Fast food products have become more popular than healthy eating practices in most metropolitan families. A significant number of school-age children often consume fast food, which is characterised by its high calories, fatty tissue, simple sugar, salt, and inadequate fibre and vitamins. Recent research has examined the impact of nutrition on fullness and satisfaction. After consuming a specific amount of food, hunger is suppressed; on the other hand, satiety is the duration of time during which hunger is absent in between meals.

It is vital to measure the satiating effects of different macronutrients, since their capacity to increase fullness and minimise future meal consumption differs. Proteins are more likely to satisfy hunger than carbs, which can also reduce the quantity of food consumed during the following meal. In comparison, proteins and carbs have a more powerful satiating impact than fats. High-lipid meals encourage passive overconsumption since they have a high energy density, which increases intake of energy. People who eat meals heavy in fat have an increased likelihood of gaining weight and developing obesity.

The prevalence of overweight and obesity in children has been strongly linked to their intermittent consumption of snacks during meals and their growing preference for sugary drinks, a trend that has been on the rise in recent decades.[30,31]

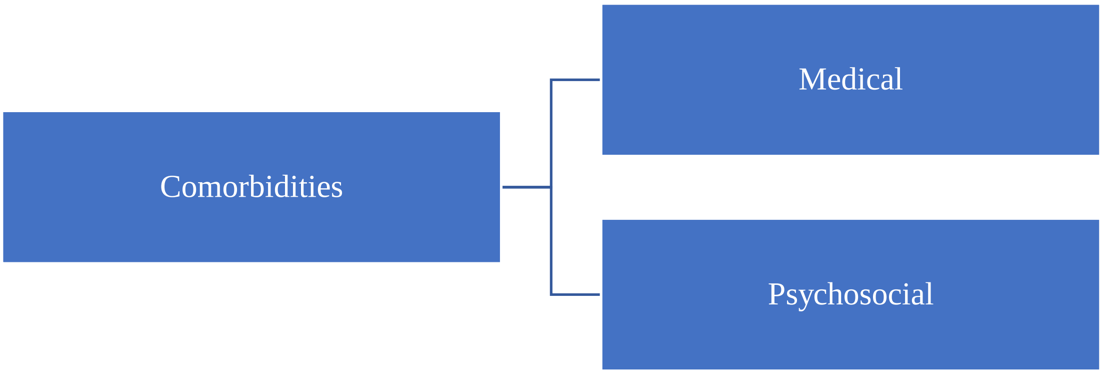
Behavioural changes:

Stress levels in adults and children have increased as a result of urbanisation and modernization. The majority of individuals turn to food to decompress, which raises calorie intake.[34]

Stress reduces the amount of time that is spent sleeping. Chronic sleep deprivation raises ghrelin and orexin levels and lowers leptin levels, which increases hunger and promotes obesity.

Other eating behaviours linked to adolescent obesity include:[34]

1) Searching for food despite not feeling hungry, leading to consuming excess calories.
2) Lacking control over eating habits.
3) Turning to food when experiencing emotions like sadness, boredom, or restlessness.
4) Using food as a form of reward.
5) Sneaking or hiding food intake.
6) Engaging in binge-eating and resorting to unhealthy practices
7) Skipping/ delaying breakfast.
8) Overeating in the evening.
9) Waking up at night to eat excessively.
10) Frequently dining at fast-food establishments.



Comorbidities:

Fig 8: Types of comorbidities related to obesity

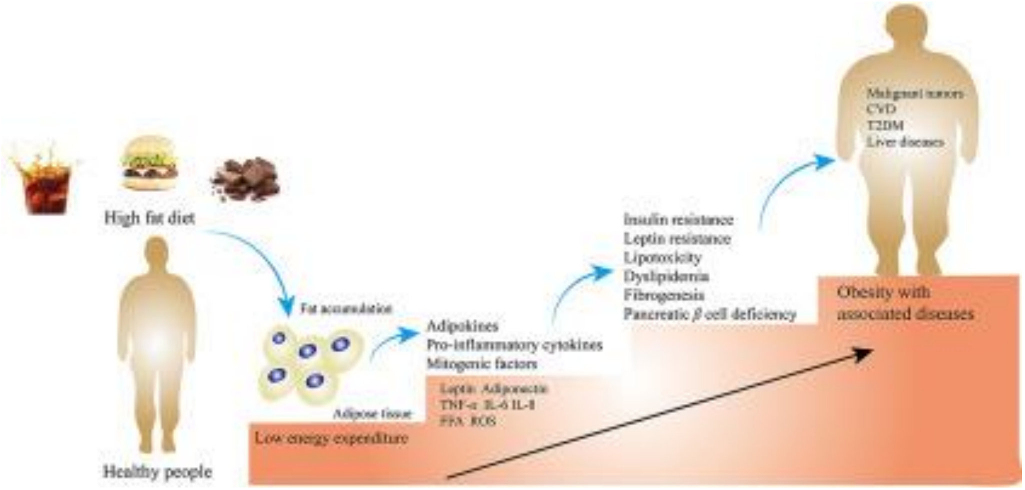


Fig 9: Pathophysiology of obesity and its related diseases

The primary cause of the pathophysiology of obesity-related comorbidities is tissue hypoxia, which results in inflammation and the production of markers that heighten endothelial vascular permeability and dysfunction.[35]

The majority of our body's systems are impacted by medical co-morbidities.

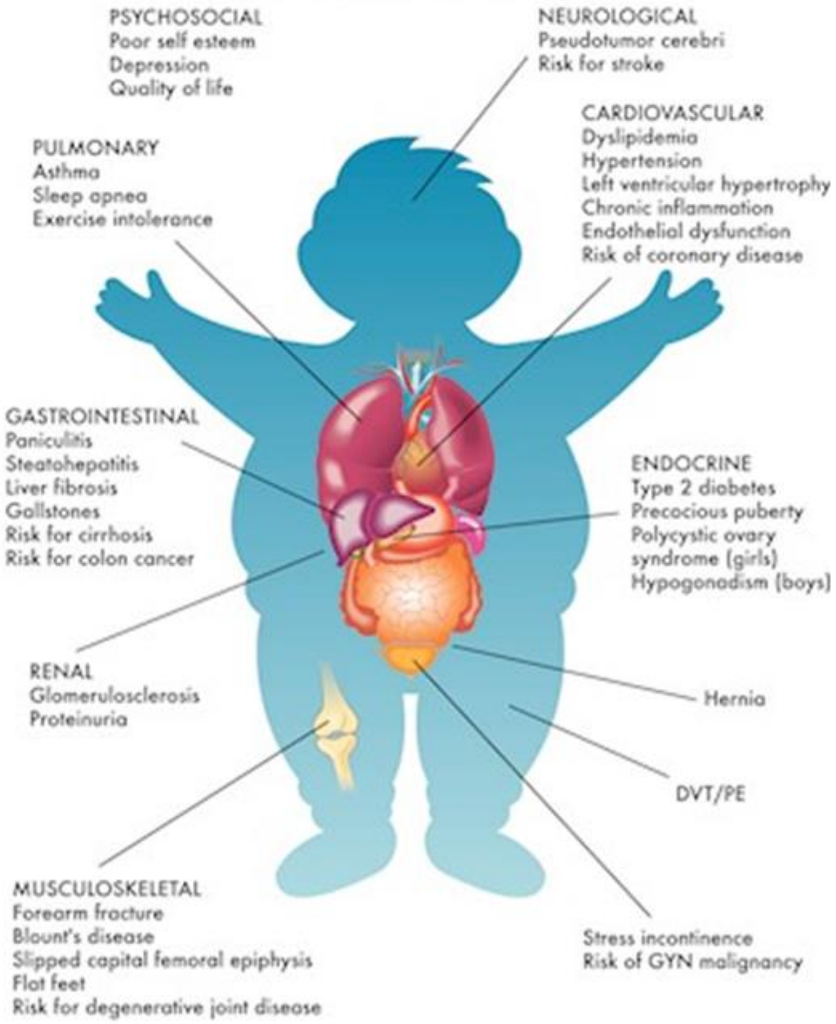


Fig 10: Medical Complications related to childhood obesity

Metabolic Syndrome:

Metabolic Syndrome affects approximately 20% of individuals aged 20 and above, and 40% of those aged 40 and above, based on statistics for adults. The incidence is increasing in India.[36]

Metabolic syndrome comprises a collection of health conditions that frequently manifest in conjunction, such as hypertension, a deficiency of high-density lipoprotein (HDL) cholesterol, obesity, elevated fasting Triglycerides (TG), Insulin resistance (IR), and impaired glucose tolerance. The confirmation of metabolic syndrome, as per the criteria established by the World Health Organisation (WHO), requires the coexistence of insulin resistance and several other contributing factors. The following are considered to be risk factors: elevated plasma triglyceride levels, elevated systolic blood pressure, diastolic blood pressure, low HDL cholesterol levels, BMI > 30, or a Waist-Hip ratio greater than 0.9 in men and 0.85 in women. Furthermore, an elevated rate of urinary albumin excretion or an albumin-creatinine ratio that satisfies particular thresholds may also serve as indicators of metabolic syndrome.[37]

Insulin resistance:

Insulin resistance is a lack of plasma insulin at average concentrations to hinder very low-density lipoprotein (VLDL) production, reduce hepatic glucose output, and promote peripheral glucose clearance. Insulin resistance induces an surge in insulin excretion. The subsequent hyperinsulinemia temporarily counteracts the insulin resistant and sustains homeostatic blood glucose levels. However, overt diabetes manifests in conjunction with relative beta cell deficiency.[38] The increasing recognition of the ethnic group Indians as having a higher prevalence of resistance to insulin is gaining traction.

A multitude of epidemiological investigations conducted worldwide have demonstrated that the origins of insulin resistance can be traced back to the early stages of foetal development. Low birth weight and, specifically, retardation of intrauterine growth followed by rapid recuperation of growth and proportionate postnatal adiposity have been associated with insulin resistance. [39,40]

Genes involved in insulin resistance

The aetiology of insulin resistance is multifaceted. Consequently, lipodystrophy, obesity, and insulin resistance arise from various molecular mechanisms involving the breakdown of lipids, insulin receptor signalling pathway, cytokines, hormone-binding proteins serine protease inhibitors (SERPINS), and other protease regulators.

The energy balance pathway is influenced by uncoupling proteins, POMC, NPY, and the sympathetic nervous system regulation pathways. The insulin-signaling pathway has been observed to undergo modifications such as insulin receptor mutations, the formation of insulin receptor self-antibodies and changes in the glycoprotein-1 and GLUT4 located in the plasma cell membrane. The lipid homeostasis system is influenced by lipoprotein lipase, adipocyte-derived hormones, PPAR-γ (peroxisomal proliferator-activated receptor), resistin, leptin and adiponectin.[41]

Birth weight and length-insulin resistance:

Small for gestational age (SGA) newborns have been found to have a higher prevalence of adult disorders such as hypertension, type 2 diabetes, and cardiovascular diseases. Rapid postnatal weight increase in an SGA newborn is a clear sign of insulin resistance.[42] According to the Early Bird Study, insulin resistance at age five was linked to weight gained following catch-up growth rather than birth weight, particularly in girls.[37] Growth patterns that occur as a result of foetal growth restriction are linked to uterine variables in mothers, including smoking, gestational diabetes, insulin resistance, and dietary constraints.

Conversely, as insulin is a potent prenatal growth hormone, decreased foetal development with SGA may be expected if a hereditary insulin resistance status was evident in utero. Unexpectedly, infants who are disproportionately large for their gestational age are also susceptible to developing insulin resistance. A documented U-shaped correlation has been observed between fasting insulin, birth weight, BMI, and adipose mass.

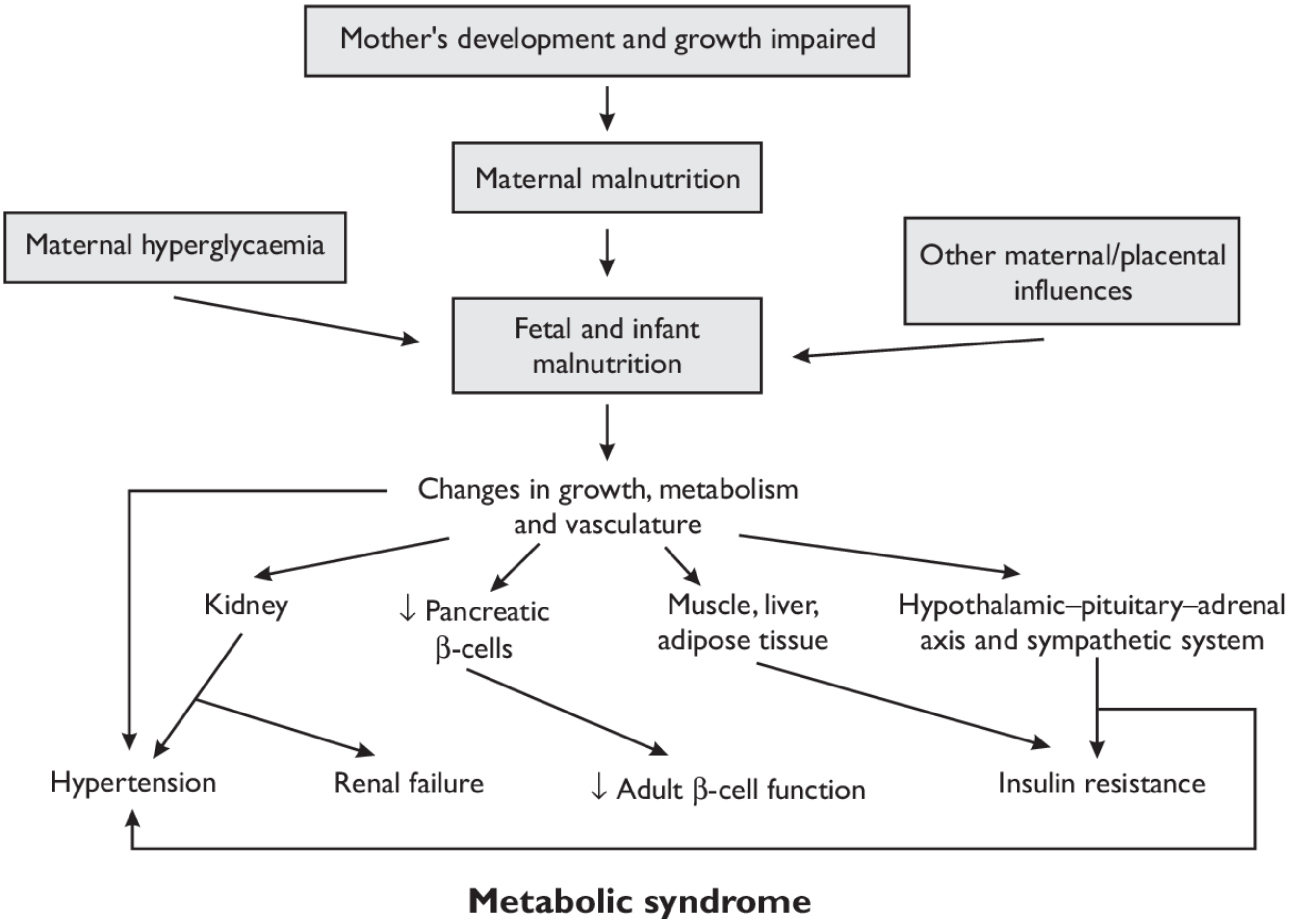
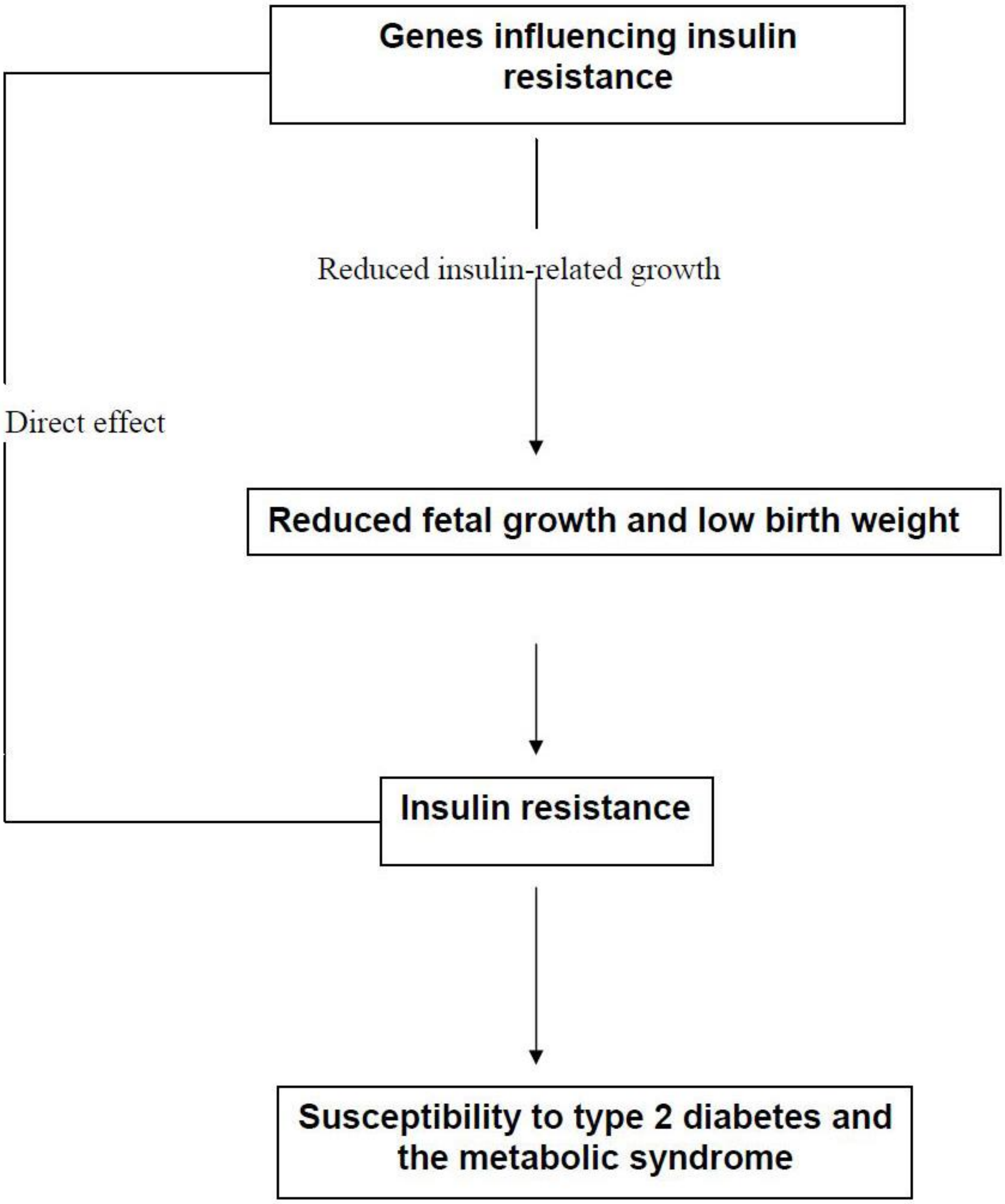


Fig 11: Thrifty Phenotype Hypothesis[43]

The Fetal Insulin Hypothesis:[44]



Magnesium's function in resistance to insulin:

Although magnesium is found all across the body, it is particularly concentrated in the heart, muscles, and bones. Because a number of factors affect the amount of serum magnesium, the concentration of magnesium in the plasma of healthy persons is rather stable throughout.

Insulin is one of the key variables that regulates magnesium levels among the many other factors that affect magnesium levels, therefore it merits special attention. However, magnesium also affects the amount and function of insulin.[45]

The physiological mechanism by which magnesium functions as a cofactor for over 300 enzymes that are implicated in the metabolism of glucose elucidates magnesium's impact on insulin resistance. In addition, magnesium serves as an additional mediator for the tyrosine kinase receptor-mediated action of insulin.[46]

Magnesium also affects the activity of phosphorylase B kinase, which releases glucose-1-phosphate from glycogen. Magnesium influences GLUT4, which in turn affects glucose translocation into the cell.

Tyrosine-kinase activity at the insulin receptor level is impaired and the intracellular calcium concentration is increased when there is insufficient intracellular magnesium present. Insulin action is compromised, and insulin resistance deteriorates as a result of these occurrences. Along with the previously mentioned process, low erythrocyte magnesium content prevents insulin from binding to its receptor by raising the membrane's micro viscosity.

The impact of magnesium on lipid metabolism also mediates its influence on insulin resistance. Magnesium is necessary for lipoprotein lipase and LCAT to increase HDL cholesterol and decrease triglycerides, respectively. Low magnesium causes lipoprotein lipase LCAT activity to drop, which in turn causes low HDL and hypertriglyceridemia.[47]

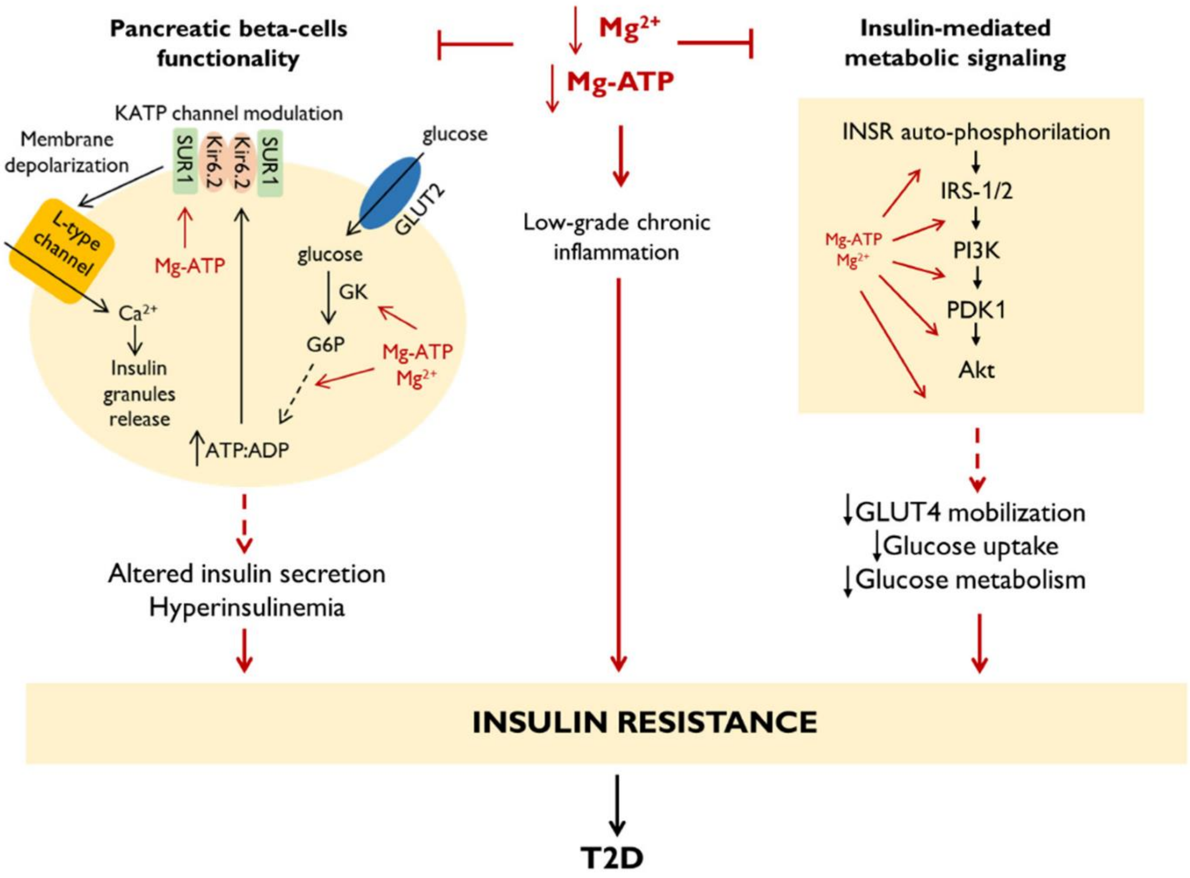


Fig 12: Magnesium in insulin resistance

Clinical features of insulin resistance syndrome:

A central obesity, distinct skin involvement, allergic diathesis, hypertension, an atherogenic dyslipidemia, early atherosclerosis, tall stature and pseudoacromegaly. Insulin sensitivity can manifest in extremely obese individuals, insulin resistance can manifest in non-obese individuals. This distinction should not be overlooked.

Patients with obesity represent diverse subgroups of insulin resistance in terms of metabolism and phenotypic manifestations, whereas people with similar body mass indices (BMIs) may differ in terms of insulin resistance and metabolic compensation. Nonetheless, the majority of people with BMIs between 35 and 40 are insulin resistant.[48]

Insulin Resistance's clinical characteristics:[49]

Features of IRS

- Acanthosis Nigricans
- White striae
- Centrepetal obesity
- Hirsutism
- Ovarian hyperandrogenism and infertility
- Dyslipidemia
- Premature atherosclerosis
- Hypertension
- Hyperurecemia/gout
- Allergies/Asthma
- NASH
- Chronic pancreatitis
- Focal glomerulosclerosis
- Glucose intolerance
- Type 2 Diabetes
- Increased cancer risk
- Increased incidence of Alzheimer's disease

Paediatric features of IRS

- Positive family history of diabetes, obesity, hypertension, CHD and stroke
- History of maternal gestational diabetes
- SGA
- Asthma/Allergic rhinitis
- Premature pubarche
- Red and white striae
- Obesity appears or worsens
- Decreasing resting energy expenditure
- Low resting fat to carbohydrate oxidation rates
- Acanthosis Nigricans
- Tall stature/Pseudoacromegaly
- Hirsutism/PCOS with adolescence
- Adipomastia/gynaecomastia
- Acute pancreatitis
- Premature atherosclerosis
- Hypertension
- Type 2 Diabetes

Diabetes:

The majority of individuals with insulin resistance do not develop type 2 diabetes. A higher risk of cancer is associated with insulin resistance, even though some individuals with it may not develop diabetes. Other conditions that they may develop include early atherosclerosis, obesity, acanthosis nigricans, raised skin tags, hypertension, dyslipidemia, hypercoagulation, PCOS, fatty liver the rate of infiltration and focal segmental glomerulosclerosis. Consequently, insulin resistance syndrome is not harmless even in the absence of diabetes.[50]

Natural history of the clinical insulin resistance syndrome:

The typical course of resistance to insulin syndrome begins in infancy due to the combination of environmental and genetic factors. As hyperinsulinism and the early onset of type 2 DM and atherosclerosis are caused by insulin resistance, it is often unclear whether condition—insulin resistance or satiety—is primarily genetically encoded.[51] Before hyperinsulinism manifests in children, there is insulin resistance and obesity. Therefore, it is possible to conceptualise the pre-existing, genetically predisposed insulin resistance as adjusting for the hyperinsulinemia, acting as a barrier to the development of impaired glucose tolerance and diabetes.

Increased insulin (especially portal) secretion, mainly in the liver and adipose tissue, results in a greater production of free fatty acids. An increase in glucose oxidation and malonyl coenzyme-A in tandem. The liver responds to a signal when fatty acids are abundant by shifting its attention from ß-oxidation to compensating increases in triglyceride and long chain fatty acid production. Generally speaking, insulin and leptin may both decrease hunger; however, high-fat meals actually stimulate appetite.

Due to elevated amounts of malonyl CoA, the liver therefore loses its sensitivity to compensatory leptin signalling, which increases ß-oxidation and blocks the insulin resistance state. Increased malonyl CoA levels inhibit fatty acid ßoxidation, which causes triglyceride buildup in the liver and muscle. This is accompanied by reduced GLUT4 translocation, poor serine phosphorylation of insulin receptor substrate-1, and decreased glucose oxidation. These occurrences in the pancreatic islets cause ß-cell death by activating caspases and raising ceramide levels. Thus, inadequate insulin production to reverse pre-existing insulin resistance leads to type 2 diabetes.

Pathologies linked to insulin resistance and hyperinsulinism:

Adipose Tissue

Insulin resistance is generally thought to be a result of obesity, particularly increased visceral fat buildup. Insulin resistance brought on by genetics may be the main factor underlying and contributing to the development of obesity. On the other hand, slender people who are not fat can also become insulin resistant.[52]

Visceral fat

Visceral fat greatly affects how insulin affects the production of glucose in the liver. The central distribution of fat in the body is more sensitive than absolute fat mass and is associated with a greater likelihood of stroke, Coronary artery disease, DM, and premature mortality. Cardiovascular morbidity is associated with both waist circumference and BMI.[53]

Leptin levels in subcutaneous fat are greater than in visceral adiposity, and subcutaneous adiposity is linked with higher levels of Leptin. Visceral fat tissue is an important store of omega-3 fatty acids, which stimulate hepatic lipogenesis and prevent glucose oxidation, due to its portal outflow[54]. Compared to subcutaneous fat, visceral fat has higher local levels of glucocorticoids receptors. The 11ßHSD1 action seen in omental adipose tissue is absent in subcutaneous adipose tissue, which results in a reduction in the conversion of inactive cortisone into cortisol. Recently, there has been a proposal suggesting that 11ßHSD1 is blocked by hormones such as growth hormone and IGF-I, whereas 11ßHSD1 activity is elevated in obesity when growth hormone levels are decreased. Insulin resistance and 11ßHSD1 activity are connected.[55–57] Visceral fat has a localised elevation of glucocorticoid hormone activity, which may contribute to the genesis of many key metabolic syndrome traits.

Urinary free cortisol levels that are biochemically high and larger abdominal striae are linked to obesity. Individuals with Cushing's syndrome have increased serum cortisol levels, while individuals with insulin resistance syndrome have moderate to normal levels; However, both groups have elevated urinary free cortisol levels. The logic behind this stems from the observation that decreased levels of corticosteroid-binding globulin are linked to insulin resistance syndrome. This leads to circulatory cortisol that is abnormally free and bioactive, as well as improved transformation of cortisone to the biologically active cortisol. Patients with insulin resistance syndrome may be clinically separated from those with Cushing's illness by their child's excessive linear development in contrast to the latter's continuous growth retardation.

Fatty liver or hepatic steatosis:

Hepatic steatosis, sometimes referred to as non-alcoholic steatohepatitis, is another effect of insulin resistance that may deteriorate over time and lead to fibrosis and inflammation. Of the adult patients with diabetes and obesity, all have moderate steatosis; half of them have steatohepatitis, and nineteen percent have cirrhosis. The sickness usually stays silent for many years. As surrogate markers of hepatic fat accumulation, elevated levels in the blood of γ-glutamyltransferase, alkaline phosphatase, aspartate aminotransferase, and the enzyme alanine aminotransferase have been proposed[58,59]. The aminotransferase aspartate to alanine aminotransferase ratio increases with fibrosis progression, however it is often less than 1.

Hypertension:

Increased renal salt absorption, elevated sympathetic nervous system activity, antagonistic nitric oxide vasorelaxation, and vulnerability to adrenergic activation elicited by free fatty acids are among the many routes by which hyperinsulinemia may lead to hypertension[60] .

An initial cause of atherosclerosis may be insulin resistance:

Adult research have demonstrated a correlation between atherosclerosis and insulin resistance. An atherogenic dyslipidemia profile and thicker artery carotid walls are associated with a higher risk of atherosclerosis. Crucially, hyperinsulinemia poses a risk for cardiovascular disease on its own. An elevated BMI was the greatest predicted childhood risk factor. Measured throughout childhood, lower levels of HDL cholesterol and higher blood pressure were linked to coronary artery calcifications.[61]

When a child approaches puberty, the aorta and coronary arteries may have fat streaks in them. The dimension of the carotid wall is a validated alternative measurement for atherosclerosis in teenagers and young adults. It is sensitive to intake of triglycerides and cholesterol, cigarette use, hypertension, BMI, and fasting hyperglycemia. Insulin resistance as well as hyperinsulinemia are associated with dysfunction of endothelial cells, an early event that occurs prior to plaque formation and is suggestive of an early stage of childhood-onset atherosclerosis.[62]

Asthma, eczema, inflammation, and weakened immunity:

Increases in erythrocyte sedimentation rates, TNF-α levels, and C-reactive protein (CRP) are indicators of inflammation that are present in type 2 diabetes and insulin resistance syndrome. BMI and CRP levels are correlated, and obesity has been shown to be the main factor influencing CRP levels in kids. It has been demonstrated that leptin increases the synthesis of proinflammatory cytokines, such as interleukin-6 (IL-6) and TNF-α, boosts macrophage phagocytosis, raises level of T-Helper 1, and suppresses T-Helper 2, cytokine making.[63]

There is a robust association with fat and asthma, particularly throughout puberty. A plausible explanation might be that obesity is a condition associated with inflammation, and T-Helper1 cytokine responses are influenced by leptin levels. There was a correlation between BMI and the rate of asthma in both boys and girls. It was observed that females who gained weight between the ages of 6 and 11 had a 7-fold increased risk of experiencing new symptoms of asthma between the ages of 11 and 13.[64]

Hypoventilation and sleep apnoea.

Excess body fat is linked to declines in vital capacity, expiratory reserve volume, overall lung capacity, and functionally residual volume. Although the increased body mass is probably the reason of this decline, other hypothesis also suggest that increasing leptin levels may be involved.[65]

Acanthosis Nigricans (AN)

An AN is a skin lesion that is often utilised as a clinical proxy for laboratory-documented insulin resistance/hyperinsulinemia and to identify a subpopulation at high risk of type 2 diabetes.

The axillae, back of the neck, antecubital fossae, and groins are among the usual locations of involvement. Less frequently, it affects the elbows, knuckles, submammary region, umbilicus, other flexural regions, and, in severe situations, the whole skin.

The level of insulin reactions to insulin resistance and the extent of anaemia are highly correlated. Usually, before AN, an oral or IV GTT is conducted to assess insulin resistance. Even during the decompensated phase of insulin resistance, when the secretion of insulin may be alternatively low or normal, AN persists. Elevated insulin levels stimulate the insulin and IGF-1 receptors on keratinocytes, leading to an up-regulation of PPARβ/δ and keratinocyte proliferation.[65]

Hyperandrogenism and reproductive abnormalities

Hirsutism, irregular menstruation, recurrent acne, bald-headedness on the scalp, hyperhidrosis, infertility, or premature adrenarche in infancy are some of the symptoms that indicate insulin resistance. Polycystic Ovary Syndrome is linked to irregular menstruation and signs of hyperandrogenism.

Hyperinsulinemia increases ovarian hyperandrogenism by lowering levels of corticosteroid-binding globulin and SHBG, increasing pituitary Leutinizing Hormone production, ovarian 17-hydroxylase and 17,20-lyase activity, and inhibiting both estradiol- and T4-stimulated SHBG synthesis.

Pseudo acromegaly

Insulin resistance typically accelerates linear and acral development, which can manifest as pseudo-acromegaly. While hyperinsulinemia stimulates linear growth by activating skeletal IGF-I receptors, absence of IGFBPs may increase IGF-I activity by making it easily and metabolically accessible. It is well known that GH release is stimulated by ghrelin, and that ghrelin levels are reduced in obesity. Leptin's direct influence on bone formation may increase the risk of pseudoacromegaly. In the face of reduced plasma GH secretion, which is characteristic with obesity, pseudoacromegaly is seen.[66]

Assessing the in vivo effects of insulin:

Distinguishing insulin resistance requires insulin and glucose measurements (OGTT), the minimal model frequently sampled iv glucose tolerance test (FSIVGTT), fasting insulin/glucose screening, and insulin/glucose clamp studies, all of which are supported by robust clinical evidence. Insulin resistance is characterised by a diminished ability of plasma insulin to remove glucose from the periphery, inhibit the production of very low density lipoprotein (VLDL), and suppress hepatic glucose at normal levels. Hyperinsulinemic levels, represented as fasting insulin concentrations surpassing 15 μU/ml, post-OGTT insulin peaks surpassing 150 μU/ml, and/or insulin levels exceeding 75 μU/ml 120 minutes after OGTT, indicate the presence of insulin resistance.

Eating a meal raises blood glucose levels and secretogogues (such as glucagon-like peptide 1) in healthy persons, which work together to promote insulin secretion. By reducing glucose synthesis and raising glucose utilisation, hyperinsulinemia in turn helps to return the plasma glucose level to normal. Consequently, the plasma glucose concentration is regulated by this "closed loop" feedback mechanism. When a person is insulin resistant, their high insulin levels cannot fully normalise their blood glucose levels, which leads to hyperinsulinemia and secondary stimulation of the β-cells. Owing to the closed-loop link between insulin production and action, it is difficult to conclude that an oral glucose tolerance test (OGTT) or other "closed loop" approach will necessarily indicate the presence of insulin resistance.[67]

Hyperinsulinemic-euglycaemic clamp technique

Using an external feedback mechanism, this method "opens the loop" between sensitivity and insulin secretion. Endogenous insulin production by the pancreas is essentially "clamped" by preserving euglycemia.[68]

Procedure:

Following an overnight fast, venous catheters are placed in the arms of the right and left patient, and three blood samples are drawn every five minutes to monitor basal insulin and glucose. A three-hour insulin infusion will begin at a rate of 1 mU/kg/min. There is a "0" next to the commencement time. 20% glucose will be infused starting at time 0. Every five minutes, the amount of plasma glucose is monitored, and the amount of glucose infused is changed to keep the level of euglycemia at 5.6 mmol/L. Insulin levels are typically assessed at 140, 160, and 180 minutes following a 2-hour research period. Usually, reaching a constant state of euglycemia requires at least two hours. It is believed that insulin sensitivity is reflected in the rate of glucose infusion.

The index of insulin sensitivity derived from a glucose clamp test (SIclamp) is calculated as M divided by the product of G and ΔI. In this equation, M represents the constant rate of glucose infusion in milligrams per minute, G stands for the stable blood glucose concentration in milligrams per deciliter, and ΔI signifies the change between the initial and stable state plasma insulin concentrations in microunits per milliliter.

Modified intravenous minimally frequent sampled glucose tolerance test:

Insulin-sensitive tissues do not experience steady-state conditions for the duration of a typical twenty-four hours. Insulin and glucose levels fluctuate after a meal, and glucose absorption occurs at a slower rate than the time sequences of insulin and glucose. The rate of glucose disposal could potentially serve as a more reliable indicator of insulin's efficacy in conjunction with a dynamic correlation between glucose, the principal nutritive carbohydrate, insulin, the principal anabolic hormone. Performing a "minimal model" IV GTT with repeated samples is one approach to accomplishing this type of evaluation. A basic model is a computer programme that represents the physics of plasma in a precise and succinct manner.[69]

Procedure:

Two vascular accesses are created by introducing bendable IV catheters into both antecubital veins following a 12-hour fasting period. A catheter is specifically assigned for the administration of glucose rather than insulin. Three blood samples are collected at 10-minute intervals in order to quantify baseline insulin and glucose levels. A solution of 25% dextrose containing glucose is administered intravenously for one minute at a rate of 0.3 grammes per kilogramme. After 20 minutes, insulin is administered at a dosage of 0.03 units per kilogram. Over the following three hours, 30 blood samples are collected at frequent intervals to estimate glucose and insulin levels.

These collected values are inputted into the MINMOD computer program (e.g., version 3, Richard N. Bergeman 1994) to assess several parameters:

First Phase Insulin Release (AIRglucose): This reflects the functionality of beta cells.

Insulin Sensitivity Index (Si): This index represents insulin's capacity to enhance the effect of glucose in normalizing its own concentration after injection.

Disposition Index (DI): Calculated as Si multiplied by AIRglucose, it signifies insulin sensitivity adjusted for the level of insulin resistance.

When glucose tolerance is measured intravenously, insulin secretion occurs in two distinct phases. Type 2 diabetes is associated with a diminished second phase response and an almost nonexistent first phase response. Nonetheless, the first period response declines significantly prior to the initiation of type 2 DM. AIR glucose is capable of forecasting the onset of diabetes in a considerable number of individuals whose glucose tolerance remains normal. The DI is a highly effective measure for detecting latent defects in the function of beta cells, while elevated AIR values suggest hyperinsulinism and can be used to forecast the rate of adipose mass accumulation.

Substitute Indicators of Insulin Sensitivity:

When it comes to administering the hyperinsulinemic-euglycemic clamp technique and the regularly sampled iv glucose tolerance test to young, obese patients, both of these methods are labor-intensive, expensive, time-consuming, invasive, and technically hard. In light of this, it is necessary to create methods that are not only simple to use but also accurate when applied to large populations. It has been shown that the insulin sensitivity indicators acquired by HOMA-IR, QUICKI, FGIR, and fasting insulin have a significant association with the Si that is evaluated by the regularly sampled intravenous glucose tolerance test in obese adolescents and adults.[38]

Fasting Insulin:

Insulin sensitivity and fasting insulin have a curvilinear connection. Insulin levels during fasting will be higher if insulin sensitivity is poor. The fasting levels of insulin will not adequately represent the insulin sensitivity of individuals or groups when comparing them, since the β-cell activity of these individuals or groups is different. When comparing the insulin that is utilised while fasting between those who have normal tolerance to glucose and those who have impaired glucose tolerance, it is shown that the latter group not only displays insulin resistance but also has a minimum of fifty percent malfunction in the β-cells.

Homeostasis model assessment index (HOMA-IR):

This is dependent on the amounts of glucose and insulin experienced during fasting. In order to calculate this, the formula that was employed is as follows.

$$\text{HOMA-IR}= \frac{\text{Fasting glucose (mmol/L)}\times\text{fasting insulin}(\mu\text{mol/ml})}{22.5}$$

There is minimal difference between fasting plasma insulin levels and plasma glucose levels in non-diabetic persons. The relationship between HOMA-IR readings and fasting insulin levels is linear in individuals without diabetes. Because β-cell activity varies across non-diabetic patients, HOMA-IR will not adequately reflect insulin sensitivity in these subjects.

Quantitative Insulin Check Index (QUICKI):

The QUICKI (Quantitative Insulin Sensitivity Check Index) is calculated by the formula

$$\text{QUICKI}=1/(\log \text{fasting insulin}(\text{micromol/ml})+\log \text{fasting glucose}(\text{mg/dl}))$$

The QUICKI results, despite the use of logarithmic adjustments, do not exhibit a linear connection with fasting plasma insulin. Furthermore, it is possible that these values might understate insulin resistance in a population that has impaired β-cell activity that is not yet visible.

According to the OGTT, insulin sensitivity is as follows:

The Stumvoll and Matzuda indices are insulin sensitivity metrics that are obtained through oral glucose tolerance testing. Clearly, a correlation exists between the insulin sensitivity determined by clamping and the proposed OGTT-derived indices. However, it is not impossible for the correlations observed to reflect islet cell response instead of insulin sensitivity, given that the OGTT-derived indices account for endogenous reaction to insulin in their calculation.
In participants with impaired β-cell secretory capacity, such as those with type 2 diabetes or impaired glucose tolerance, the application of the OGTT methodologies would lead to an inaccurate underestimation of insulin resistance due to the reduction in post-load hyperinsulinemia. This is due to the fact that OGTT-based methodologies quantify secretion as opposed to sensitivity.

Poor repeatability is another drawback. This is because gastrointestinal function—that is, stomach functioning, absorption, and G.I. hormones—varies greatly from day to day. It is concluded that rather than easily reflecting changes in insulin sensitivity, fluctuations in OGTT really reflect changes in stomach emptying, insulin secretion, and other related factors. It might not be able to support the use of the OGTT to measure insulin resistance at this time.[70]

Treatment:

Hyperinsulinemia often provides a good compensatory mechanism for insulin resistance in children, but as they approach puberty and experience elevated glucose and triglyceride levels, this mechanism may gradually fail. Even balanced hyperinsulinemia can cause a host of problems, such as atherosclerosis, fatty liver, and elevated risk of cancer.

Diet and behavioural therapy:

Exercise, such as walking or swimming for 30 to 40 minutes most days of the week, is an active way to treat a kid with insulin resistance syndrome because it causes glucose to enter muscles without the need for insulin. The secret to losing weight is calorie restriction, particularly with regard to carbohydrates. However, restrictions on animal fats should be placed in place if there is also a higher level of triglycerides.

It has been demonstrated that metformin and behavioural treatment are safe and efficient ways to increase insulin sensitivity in young patients. Effective and safe therapies for childhood obesity are family-based behavioural interventions. Reductions in insulin resistance, increases in HDL cholesterol, decreases in total cholesterol, and the restoration of ovulatory cycles have all been linked to these therapies.[71]

Pharmacologic therapy:

For insulin resistance syndrome, metformin is the recommended medication. There are several ways that metformin works to treat insulin resistance. The phosphorylation and the tyrosine kinase function of the insulin receptor are enhanced, thereby facilitating improved insulin attachment to the receptor. It remains effective despite the presence of abnormalities in the insulin receptor. It enhances peripheral glucose utilisation by stimulating phosphoinositol 3-kinase in response to insulin receptor activation, augmenting translocation of glucose transporter isoforms GLUT1 and GLUT4 to the cell membrane in diverse tissues, and expanding adenosine monophosphate kinase production in muscle and liver. It decreases the vasculopathy marker endothelin-1, increases IGFBP-1, and decreases hepatic glucose production. Hepatic lipid production is diminished through the mechanism by which metformin inhibits TNF-α expression and decouples protein-2 mRNA levels in the liver. Metformin is a secure option for the treatment of insulin resistance syndrome in kids.

The ligand-activated transcription factors that control energy metabolism, inflammation, and cell division are known as PPAR-γ (thiazolidenediones) agonists. Although they are less helpful in promoting weight reduction, PPAR-γ agonists are good in increasing insulin sensitivity.[72]

Lipid-lowering medications such as fibrates reduce triglyceride levels primarily in the liver, where PPAR-γ transcription factor plays a major role in fat oxidation, gluconeogenesis, and amino acid metabolism. When endothelial cells were pre-treated with fenofibrate, a PPAR-γ agonist, the expression of vascular cell adhesion molecule-1, CRP, fibrinogen, and IL-6 were all decreased.

The enzyme that limits the rate at which cholesterol is synthesised, 3-hydroxy-3-methyl glutaryl-CoA reductase, is inhibited by statins. Hepatocytes upregulate the expression of LDL receptors in order to offset reduced production and preserve cholesterol homeostasis. As a consequence, plasma LDL concentrations decrease as the uptake of plasma LDL, the principal extracellular cholesterol carrier, is increased. Reductions in plasma LDL levels have the potential to impede the progression of atherosclerosis and induce regression in pre-existing atherosclerotic lesions. Furthermore, statins exhibit noteworthy immunomodulatory properties, impeding the proliferation and activation of T cells and diminishing the ingress of monocytes and T lymphocytes into the arterial wall.

Low aspirin dosages deactivate the cyclooxygenase enzyme, which catalyses the production of prostaglandins G2 and H2 from arachidonic acid. Promising from these prostaglandins is thromboxane, a powerful vasoconstrictor and platelet proaggregant. Enteric-coated aspirin in small dosages is recommended. In children with dyslipidemia who are at risk for pancreatitis due to insulin resistance syndrome, aspirin may be beneficial.[73]

Surgery

A functional stomach partition can be created using restrictive surgical techniques centred around the placement of an adjustable silicone band across a stomach fundal pouch. Restrictive methods work well to reduce the amount of solid food consumed, but consuming a lot more liquid high-calorie meals may impede weight reduction. Children should usually only get intestinal bypass surgery if they have potentially fatal problems like sleep apnea.[74]

Past literature:

The objective of a study by Elik N et al[75] was to establish a correlation between blood magnesium levels and insulin resistance and childhood obesity. The results indicated that the serum magnesium levels of the IR (+) obese group were significantly reduced in comparison to the control group (p=0.014). Simultaneously, within the IR (-) obese cohort, a positive correlation (r = –0.28, p = 0.03) was observed between magnesium levels in the blood and (BMI-SDS).

The objective of the study conducted by Huerta MG et al.[76] was to determine whether obese children have a magnesium deficiency in their blood or serum, and if so, whether this may be associated with IR. The results indicated that children classified as obese had significantly reduced levels of magnesium in their serum compared to children classified as slender (0.801 ± 0.012 mmol/l) (P = 0.009). A positive correlation was observed between QUICKI and fasting insulin; an inverse relationship was observed between serum magnesium and the latter (rs = 0.36 [95% CI 0.59 to 0.08]; P = 0.011). The intake of magnesium from the diet was significantly diminished in children who were overweight (obesity: 0.12 ± 0.004 mg/kcal vs. lean: 0.14 ± 0.004 mg/kcal). There was a significant direct correlation between dietary magnesium intake and QUICKI (0.43), while fasting insulin had an inverse relationship with magnesium intake (-0.43 [-0.64 to -0.16]; P = 0.002).

A study was conducted by Jose B. et al.[77] to investigate the correlation between blood magnesium levels and the elements of the metabolic syndrome in infants and adolescents. Forty individuals, aged four to fourteen, were separated into 53 normal weight and 55 overweight categories. The levels of blood magnesium, sugar, lipids, and insulin were assessed. The dietary intake of magnesium was calculated. Upon conducting an analysis, the authors ascertained that the serum magnesium levels in the overweight group (2.12 ± 0.33 mg/dL) were notably diminished in comparison to the normal weight group (2.56 ± 0.24 mg/dL, $P<0.001$). Furthermore, the dietary magnesium intake of the overweight group (adjusted for calorie intake) was found to be higher than the normal weight group. There was an inverse correlation observed between serum magnesium levels and insulin levels, WC, SBP, DBP and BMI.

A research by Suliburska J et al.[78] sought to determine if blood mineral concentrations in obese adolescents were associated with insulin resistance. The findings demonstrated that the concentrations of insulin and serum glucose were considerably greater in the obese participants. The HOMA-IR index levels were much higher than those seen in the group with normal weight. The blood concentrations of zinc, calcium, and magnesium were considerably lower in the obese participants than in the normal weight group. Serum zinc content and insulin concentration as well as the HOMA-IR score were shown to be strongly inversely correlated.

Guerrero-Romero and Rodriguez-Morán79 compared 192 individuals with metabolic syndrome to 384 controls using a cross-sectional design. In this particular case, the metabolic syndrome was operationally defined as the coexistence of two or more of the subsequent symptoms: hyperglycemia (≥7.0 mmol/L), hyperglycemia, and hypertension (≥160/90 mm Hg). The average blood magnesium concentrations of individuals with metabolic syndrome were 1.8 ± 0.3 mg/dL, whereas the mean values for normal patients were 2.2 ± 0.2 mg/dL ($p < 0.00001$). There is an independent association between low blood magnesium concentrations and the metabolic syndrome. Moreover, among all the symptoms of metabolic syndrome, hypomagnesemia had the highest correlation with hypertension and dyslipidemia.

Small research with 27 individuals who had poorly managed type 2 diabetes mellitus was carried out by Lima et al.[80] According to their findings, around 31% of patients had reduced intracellular magnesium levels, while 75% of patients had lower serum magnesium concentrations. Additionally, they discovered a negative relationship between BMI, glycosylated haemoglobin (HbA1c), and intracellular magnesium concentrations.

Mayer-Davis et al. [81] evaluated the dietary habits of more than 1,600 children (10–22 years of age) who had been diagnosed by a physician with type 1 or 2 DM as part of the SEARCH for Diabetes in Kids research. Dietary intake was measured utilising a questionnaire about food frequency that had been validated for the age group as well as multiple racial and ethnic groups. A significant reduction in magnesium intake was observed among people with type 2 diabetes in comparison with people with type 1 diabetes ($p < 0.01$). Children aged 10 to 14 with type 1 diabetes mellitus ingested an estimated 272 mg of magnesium per day, whereas children of the same age group with diabetes type 2 consumed 244 mg.

Simsek et al.[82] assessed the correlation among magnesium and diabetes by comparing information from 34 newly identified kids with diabetes type 1 mellitus to that of 21 healthy controls who were matched in age and gender. A variety of methodologies were employed to evaluate magnesium. The magnesium concentrations in the plasma and erythrocytes of children diagnosed with type 1 diabetes mellitus were significantly lower than those of healthy controls. However, the plasma magnesium concentrations of all participants fell within the expected range. In contrast with control subjects, paediatric patients diagnosed with type 1 diabetes mellitus exhibited a significantly elevated urinary magnesium excretion (7.12 ± 2.18 vs. 4.0 ± 1.35 mmol/g of creatinine. Furthermore, the magnesium tolerant test demonstrated that children diagnosed with diabetes mellitus retained a greater percentage of magnesium in comparison to the control group (16 ± 7%) ($p < 0.001$). It might be prudent, according to these researchers, to monitor the magnesium levels of children with diabetes mellitus.

Zaakouk AM et al.[83] conducted a study with the purpose of evaluating the blood magnesium levels in obese adolescent and examining the potential correlation between these levels and the severity of obesity as well as the serum lipid profile. Subsequently, 50 obese individuals ranging in age from 2 to 16 were enrolled, followed by 50 healthy, normal-weight subjects of identical age and gender who functioned as control subjects. In contrast to normal weight controls, obese individuals exhibited substantially decreased levels of serum magnesium and HDL cholesterol, as well as total and LDL cholesterol, triglycerides, and SBP and DBP. The results indicated that serum magnesium had a moderately negative association with both total cholesterol and LDL cholesterol, but did not correlate with triglycerides and HDL cholesterol. However, there was a significant and severe negative relationship between serum magnesium and the level of obesity. There was a statistically insignificant correlation between the degree of obesity and triglycerides and HDL cholesterol, but a significant, moderately positive correlation with total cholesterol and LDL cholesterol.

A study was conducted by ul Hassan SA et al.[84] to examine the association between magnesium levels and obesity and overweight. The researchers compared the average magnesium levels of overweight and obese children to those of normal weight controls. In contrast to the normal weight group, the overweight and obese group (2.08 ± 0.211 mg/dl) exhibited significantly diminished blood magnesium levels. A clear and significant inverse correlation was observed between serum magnesium levels and body mass index.

MATERIAL AND METHODS

Study Design: The study was a prospective case-control type conducted at the Pediatric OPD of Shri B M Patil Medical College Hospital and Research Centre, B.L.D.E. (Deemed University), Vijayapura, Karnataka.

Duration: The study took place over 1.5 years, from September 2022 to September 2023.

Study Population:

Inclusion Criteria:

Cases: Children between the ages of 5 to 16 years who satisfied the diagnostic criteria for overweight or obesity according to the 2015 revised IAP growth charts were enrolled.
Controls: Healthy individuals who participated in immunisation clinics and matched age and gender were enrolled as controls.

Exclusion Criteria:

- Children who have secondary causes of obesity, such as those with diabetes mellitus, hypothyroidism, genetic syndrome, or Cushing syndrome.
- Children who have medical complications that increase their risk of developing hypomagnesemia, such as chronic kidney and liver disease, are excluded.
- Children receiving long-term drug therapy (e.g., diuretics, amphotericin) that may modify serum magnesium levels.

Sample Size: The study aimed for a total sample size of 110 (55 in each group - overweight and normal weight) using G*Power ver. 3.1.9.4 software.

Procedure: Subjects meeting the inclusion criteria were admitted to the pediatric medical ward. After obtaining informed consent, the following assessments were conducted:

- History: Extensive clinical history encompassing factors such as the duration of obesity, medication usage, obesity in the family, lipid disorders, and hypertension were taken.
- Clinical Examination: Measurement of weight, height, waist circumference, and blood pressure were done.
- Laboratory Investigations: Parameters such as blood sugar, HbA1C, serum insulin, lipid profile, Na+, K+, Ca2+ and magnesium were measured in fasting blood.
- Insulin Resistance Index: Calculation of QUICKI and HOMA-IR as estimates of insulin resistance.

Case definitions:

- Overweight and Obesity: Defined according to the revised I.A.P. growth charts in 2015.
- Overweight: Body mass index (BMI) ranging from 23rd to 27th percentiles of the adult population.
- Body Mass Index (BMI) Calculation: The BMI is determined by dividing weight in kilogrammes (Kg) by height in metres squared (m^2). The revised I.A.P. growth charts 2015 utilised BMI values to facilitate classification.

Insulin Resistance Index:

The HOMA-IR, QUICKI, and FGIR are insulin resistance estimations that have been computed. The HOMA Index is determined by dividing the fasting glucose concentration (mmol/L) by the fasting insulin concentration (µu/ml).

• QUICKI: computed as 1/[logarithm of glucose concentration (mg/dL) plus logarithm of fasting insulin concentration (µu/mL)].

Statistical Analysis: The information was entered into Microsoft Excel, and SPSS Version 20 was utilised to conduct the statistical analysis. Descriptive statistics were calculated to provide means, standard deviations, counts, percentages, and diagrams. For ordinarily distributed continuous variables, the independent sample t-test was utilised; for non-normally distributed variables, the Mann-Whitney U test was applied; and for categorical variables, the Chi-square/Fisher's exact test was applied. Consideration was given to significance at p0.05 (two-tailed).

RESULTS

Table 4: Age distribution

Age (months)	**Case**	**Control**
Mean	140.51	146.18
SD	29.82	31.25

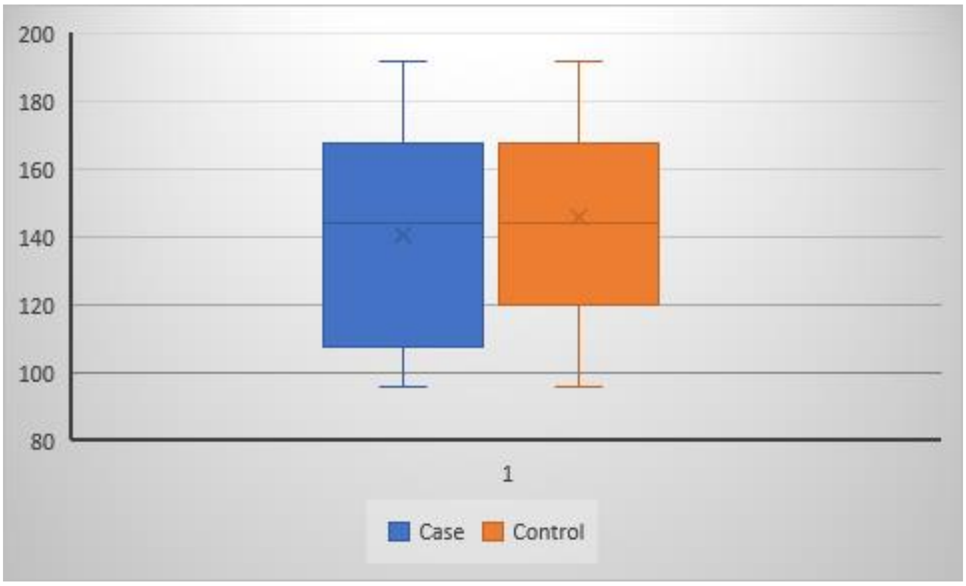


Fig 13: Age distribution

Table 5: Gender distribution

Gender	Case		Control	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Male	28	51	28	51
Female	27	49	27	49

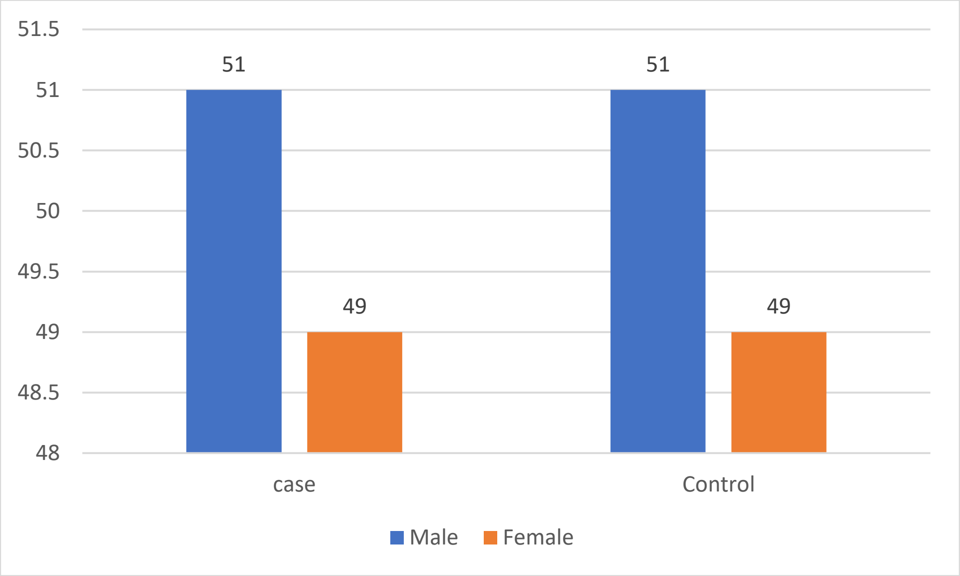


Fig 14: Gender distribution

Table 6: Family history of obesity

Family history of obesity	**Case**		**Control**		**P value**
	Frequency	**Percentage**	**Frequency**	**Percentage**	
Yes	25	45.4	29	52.7	0.446
No	30	54.5	26	47.3	

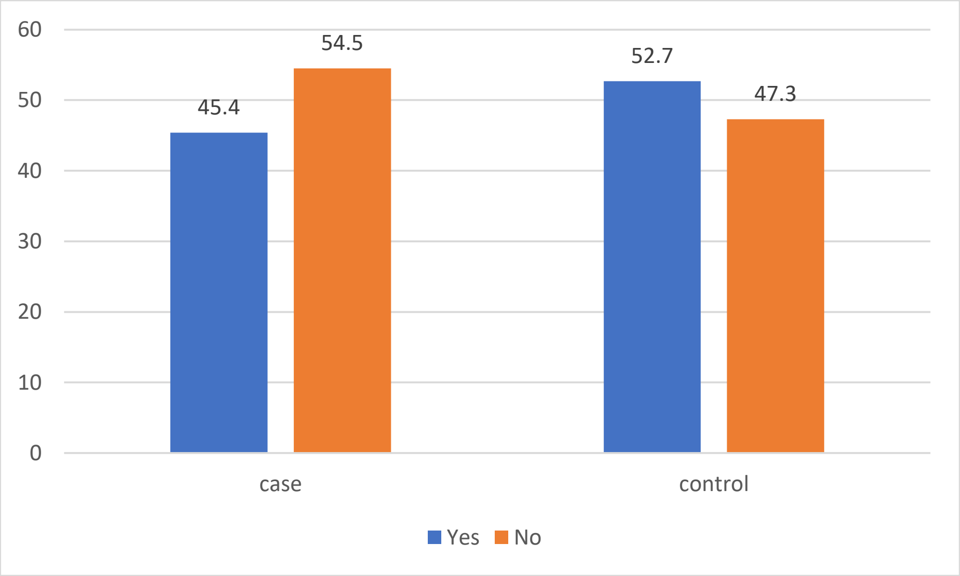


Fig 15: Family history of obesity

Table 7: Family history of diabetes

Family history of diabetes	**Case**		**Control**		**P value**
	Frequency	**Percentage**	**Frequency**	**Percentage**	
Yes	19	34.5	23	41.8	0.432
No	36	65.5	32	58.2	

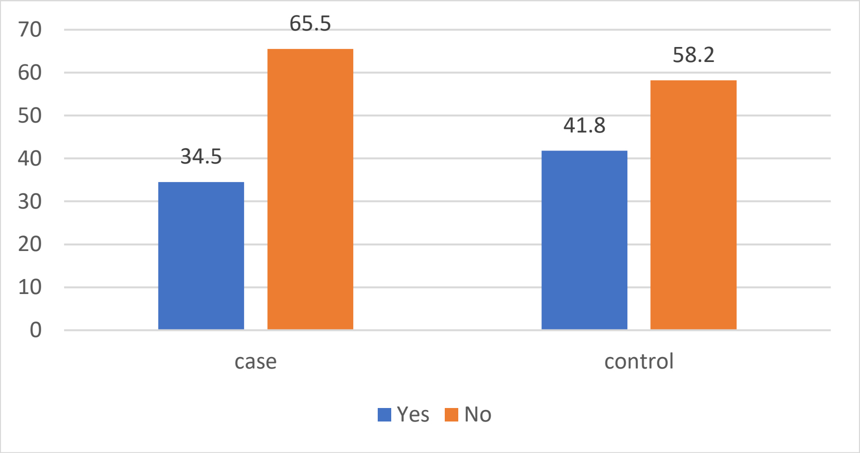


Fig 16: Family history of diabetes

Table 8: Family history of hypertension

Family history of hypertension	**Case**		**Control**		**P value**
	Frequency	**Percentage**	**Frequency**	**Percentage**	
Yes	32	58.2	26	47.3	0.252
No	23	41.8	29	52.7	

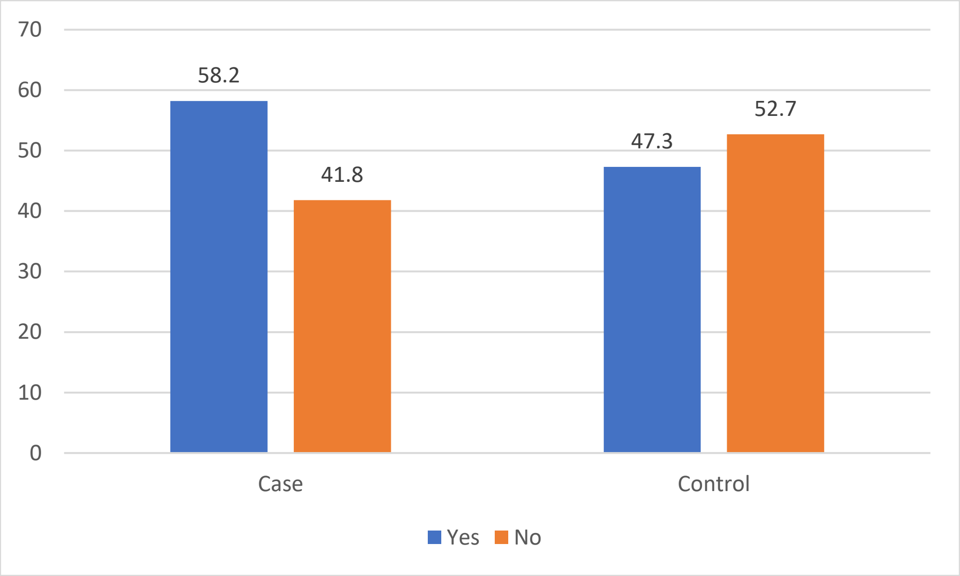


Fig 17: Family history of hypertension

19 (34.5%),13 (23.6%) and 23 (41.8%) of the cases had <2, 2 – 5 years and > 5 years, duration of obesity among the cases

Table 9: BMI distribution

BMI (kg/m^2)	**Case**	**Control**	**P value**
Mean	31.33	18.04	<0.001
SD	4.35	2.3	

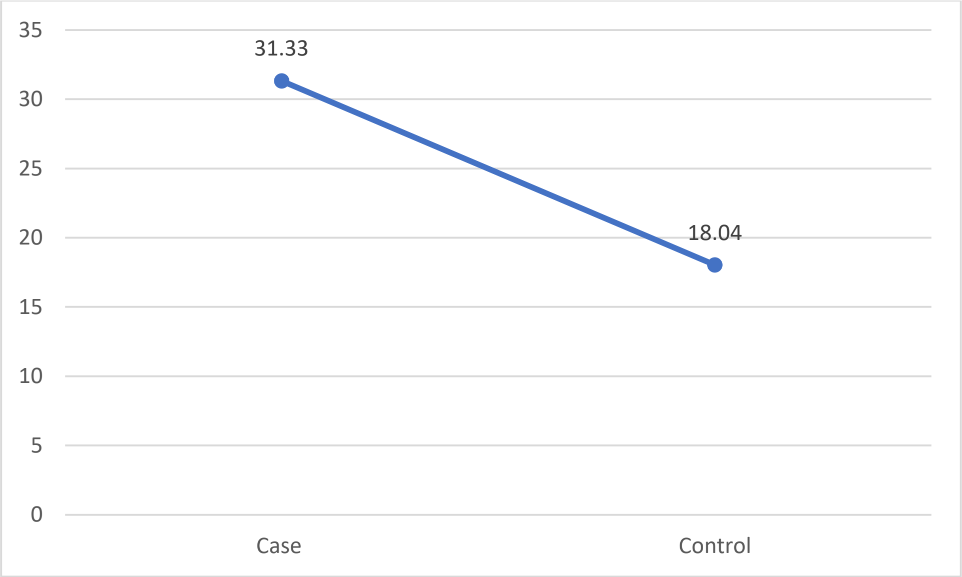


Fig 18: BMI distribution

Table 10: Percentage body fat distribution

Percentage body fat	Case	Control	P value
Mean	43.31	21.46	<0.001
SD	4.20	3.59	

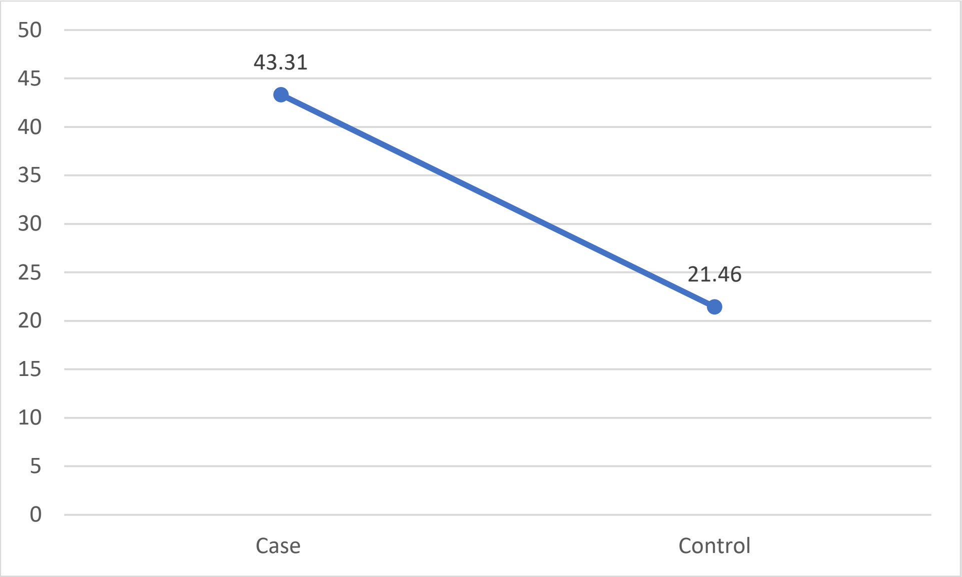


Fig 19: Percentage body fat

Table 11: Systolic Blood pressure

SBP (mmHg)	Case	Control	P value
Mean	98.36	100.05	0.223
SD	7.64	7.39	

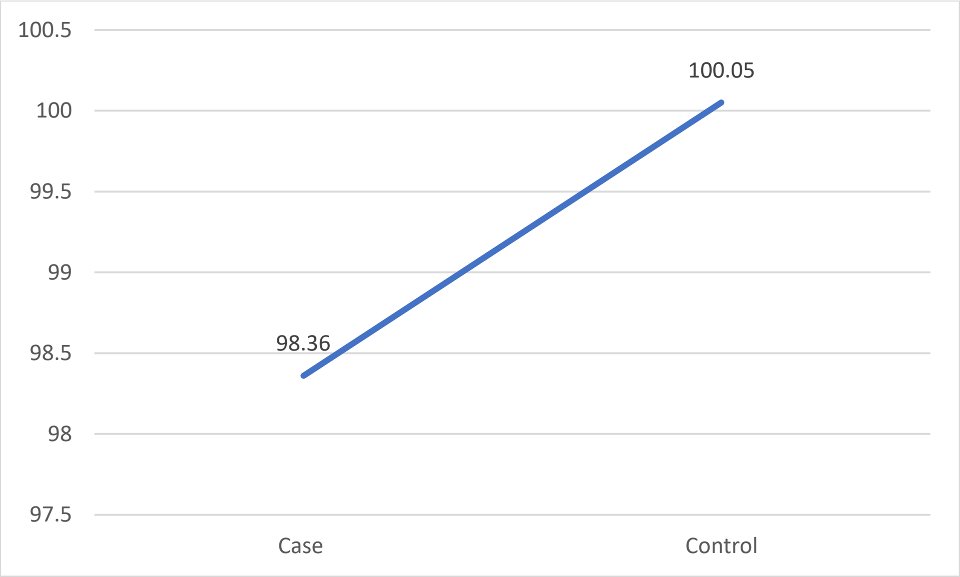


Fig 20: Systolic Blood pressure

Table 12: Diastolic Blood pressure

DBP (mmHg)	**Case**	**Control**	**P value**
Mean	65.27	65.82	0.567
SD	5.04	4 98	

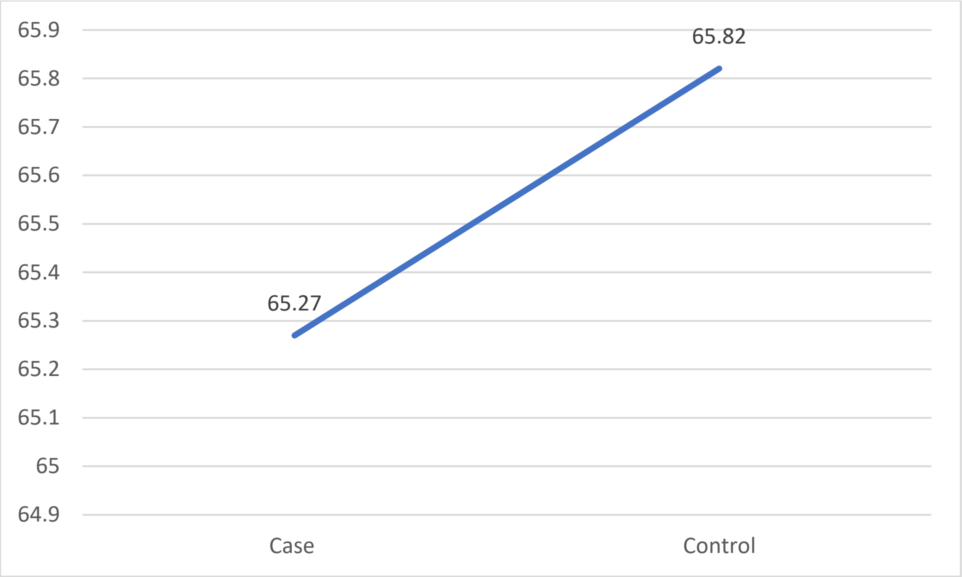


Fig 21: Diastolic Blood pressure

Table 13: Fasting glucose

Fasting glucose (mmol/l)	**Case**	**Control**	**P value**
Mean	5.04	5.03	0.955
SD	0.58	0.56	

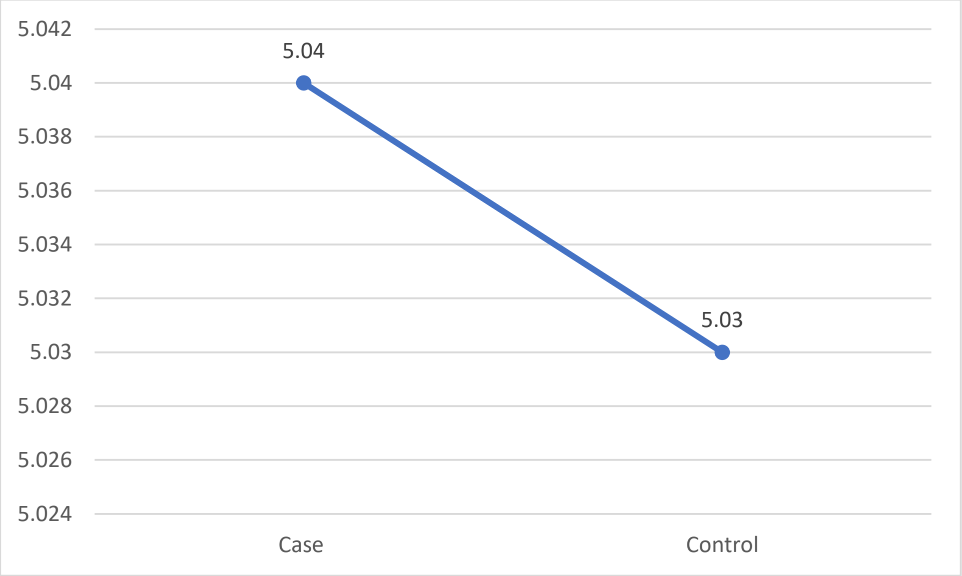


Fig 22: Fasting glucose

Table 14: HbA1c

HbA1c (%)	Case	Control	P value
Mean	5.00	4.91	0.453
SD	0.55	0.59	

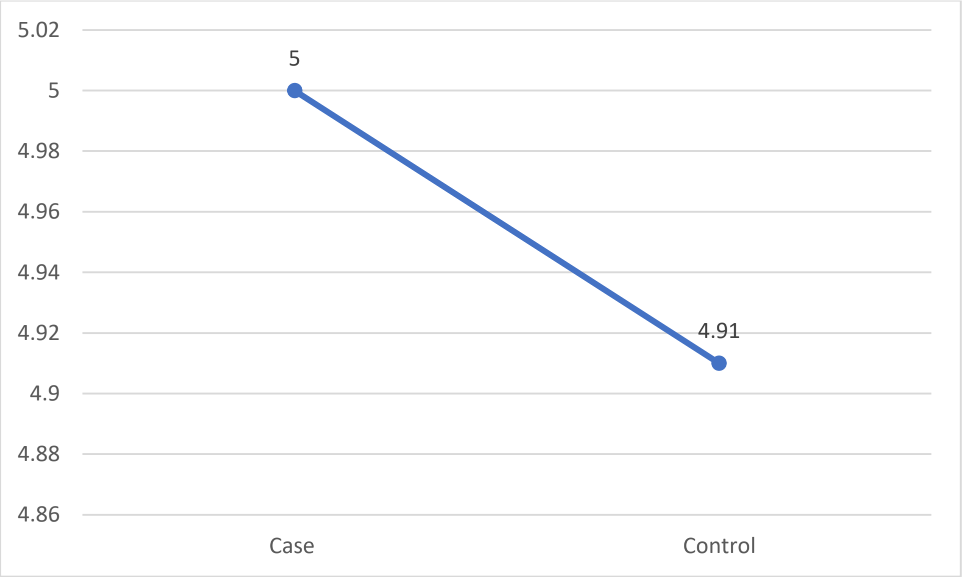


Fig 23: HbA1c

Table 15: Fasting insulin

Fasting insulin (µu/l)	**Case**	**Control**	**P value**
Mean	19.53	7.98	<0.001
SD	4.59	1.74	

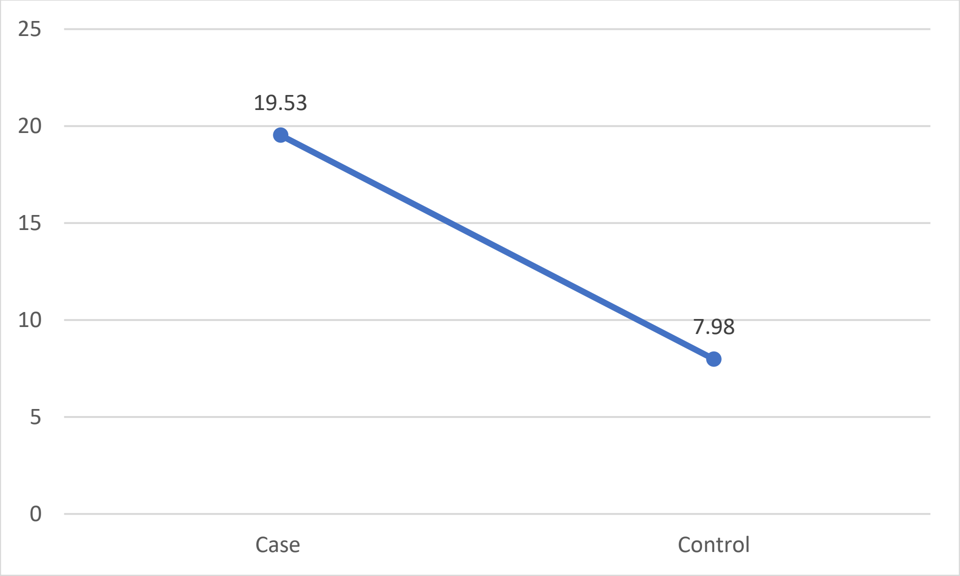


Fig 24: Fasting insulin

Table 16: HOMA

HOMA	Case	Control	P value
Mean	4.35	1.78	<0.001
SD	1.08	0.42	

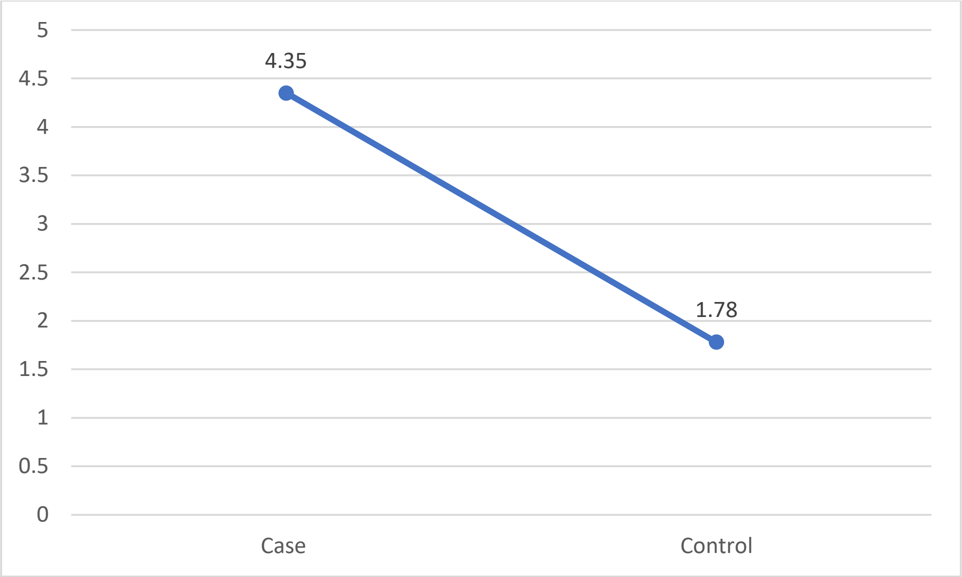


Fig 25: HOMA

Table 17: QUICKI

QUICKI	Case	Control	P value
Mean	0.309	0.351	<0.001
SD	0.0103	0.0131	

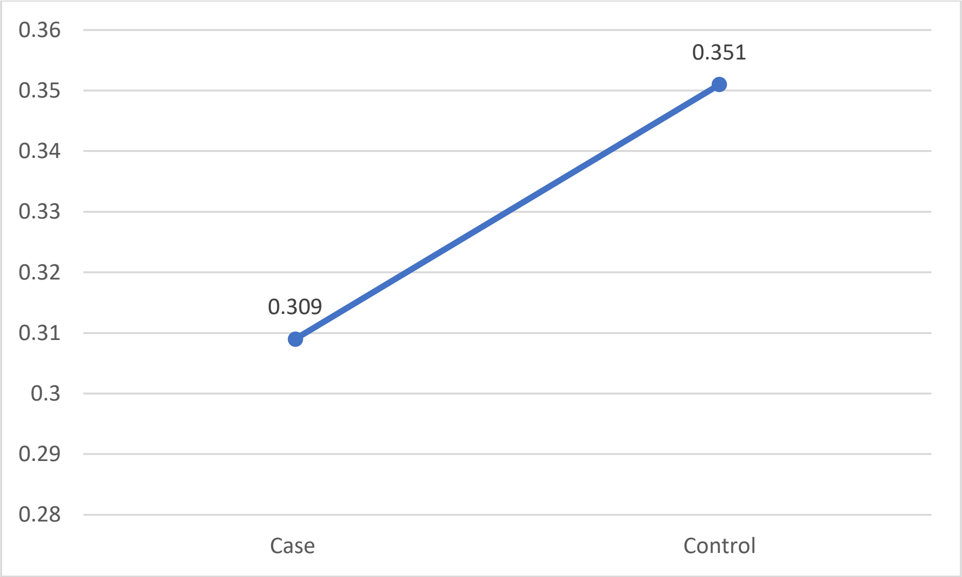


Fig 26: QUICKI

Table 18: Cholesterol level

Cholesterol (mg/dl)	**Case**	**Control**	**P value**
Mean	179.64	132.16	<0.001
SD	11.43	12.24	

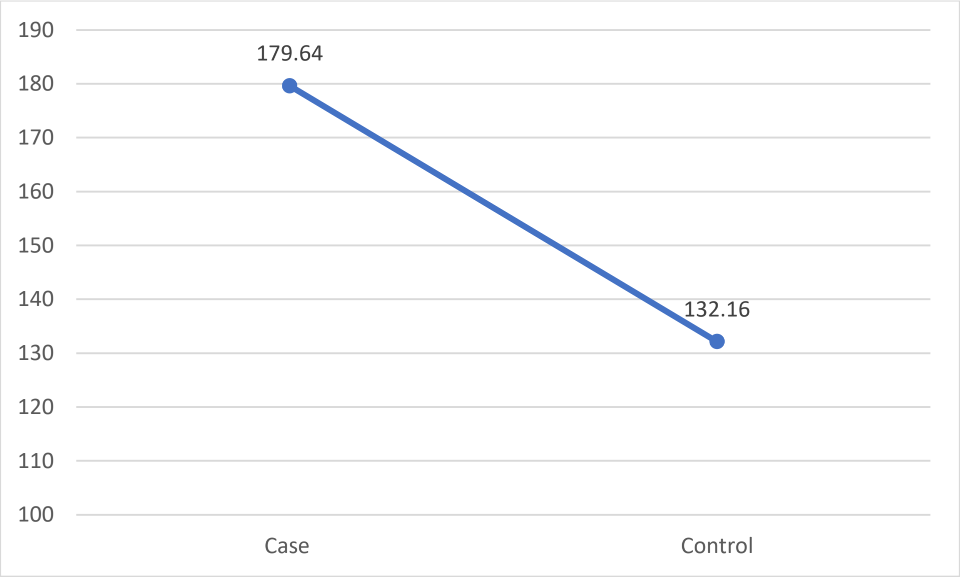


Fig 27: Cholesterol level

Table 19: Triglycerides level

Triglycerides (mg/dl)	**Case**	**Control**	**P value**
Mean	152.12	93.6	<0.001
SD	14.38	17.33	

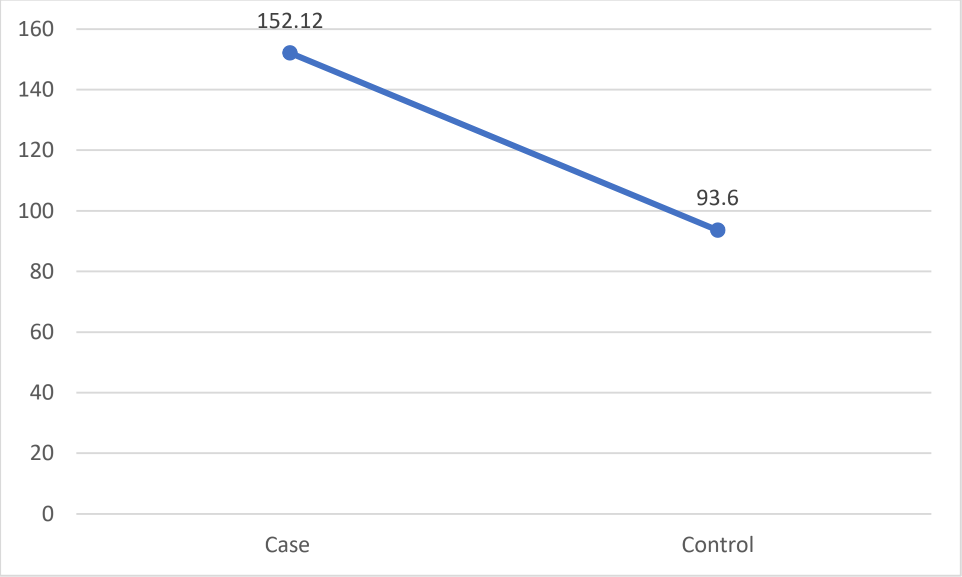


Fig 28: Triglycerides

Table 20: LDL level

LDL (mg/dl)	Case	Control	P value
Mean	124.89	85	<0.001
SD	2.81	14.41	

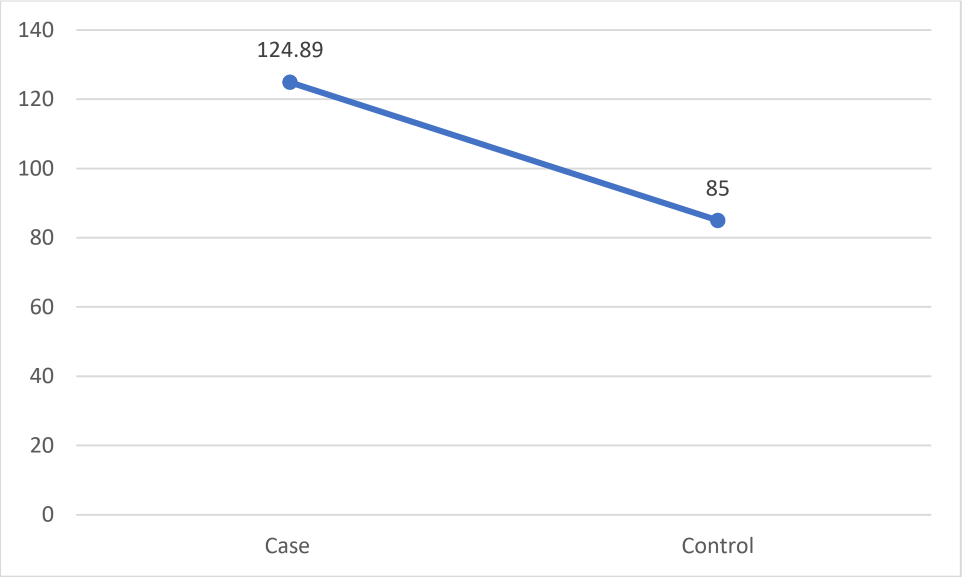


Fig 29: LDL level

Table 21: HDL level

HDL (mg/dl)	Case	Control	P value
Mean	24.65	31.73	<0.001
SD	3.08	8.05	

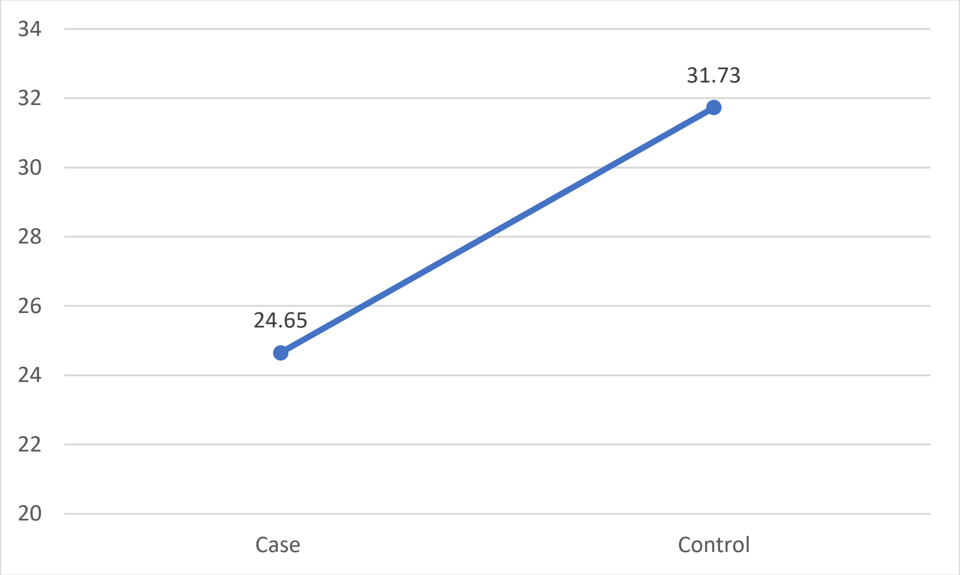


Fig 30: HDL Level

Table 22: Serum magnesium

Serum magnesium (mEq/l)	**Case**	**Control**	**P value**
Mean	1.03	1.85	<0.001
SD	0.54	0.56	

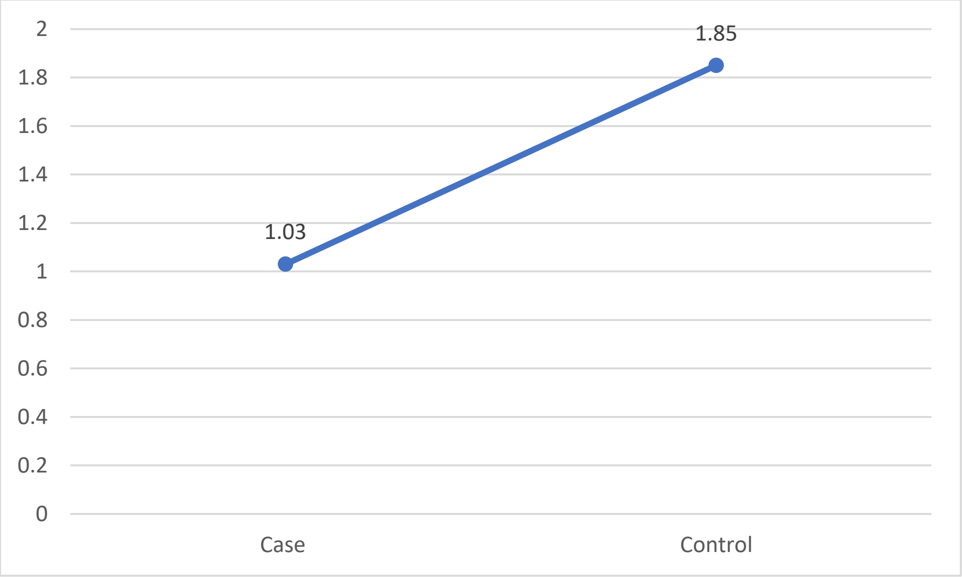


Fig 31: Serum magnesium level

Table 23: Serum calcium

Serum calcium (mEq/l)	**Case**	**Control**	**P value**
Mean	10.05	10.11	0.552
SD	0.57	0.62	

Fig 32: Serum calcium level

Table 24: Serum sodium

Serum sodium (mEq/l)	**Case**	**Control**	**P value**
Mean	140.91	140.44	0.359
SD	2.81	2.64	

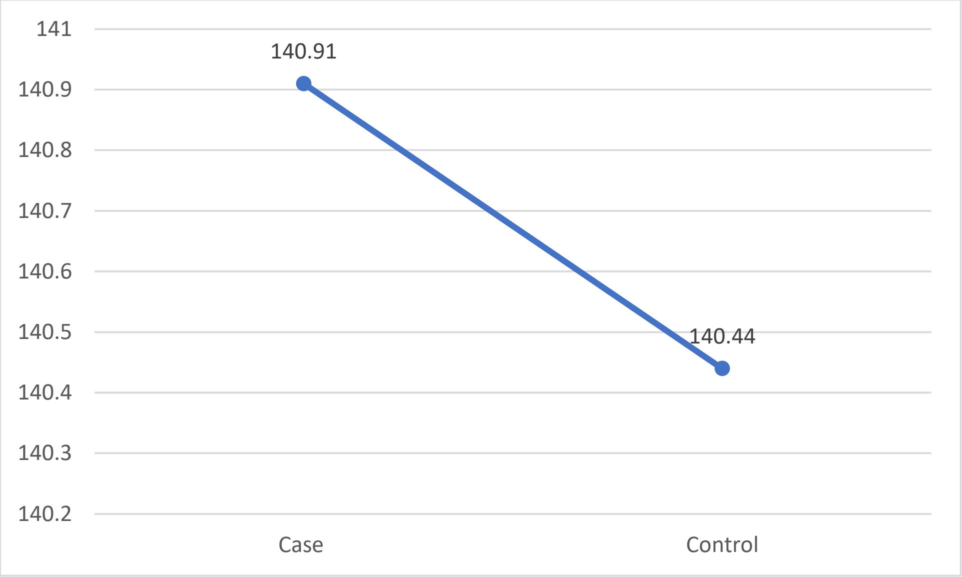


Fig 33: Serum sodium level

DISCUSSION

The primary objective of the current investigation was to examine the correlation between insulin resistance and serum magnesium levels in children aged 5 to 16 years who are overweight. The age distribution analysis revealed a non-significant difference in mean age between cases (140.51 months) and controls (146.18 months) with a p-value of 0.323. This suggests a balanced age distribution between the groups, minimizing the potential influence of age as a confounding factor in subsequent analyses.

Examining gender distribution, both cases and controls demonstrated an even split, with 51% males and 49% females in each group. The p-value of 1.000 indicates no significant gender disparity, ensuring a comparable representation of both genders in the study.

The p-values for family history of obesity, diabetes, and hypertension did not differ significantly between the cases and controls; they were 0.446, 0.432, and 0.252, respectively. This implies that the prevalence of family history for these conditions is similar in both groups, minimizing their potential impact as confounding variables.

Moving to anthropometric measurements, BMI distribution and percentage body fat distribution exhibited significant differences between cases and controls ($p < 0.001$). Cases demonstrated substantially higher mean BMI (31.33 kg/m^2) and percentage body fat (43.31%) compared to controls (18.04 kg/m^2 and 21.46%, respectively), highlighting the significant impact of overweight status on these parameters.

The significantly higher BMI, percentage body fat, fasting insulin, HOMA, QUICKI, cholesterol levels, triglycerides, LDL, and lower HDL levels in overweight children compared to controls suggest a clear association between these physiological parameters and the presence of excess weight. The non-significant differences in serum calcium ($p = 0.552$) and serum sodium ($p = 0.359$) between cases and controls indicate that these electrolytes are unlikely to contribute significantly to the observed differences in insulin resistance among overweight children.

Serum magnesium levels differ significantly among cases and controls, according to the findings. Overweight children have a mean serum magnesium level of 1.03 mEq/l, while controls exhibit a notably higher mean of 1.85 mEq/l ($p < 0.001$). This substantial discrepancy raises intriguing implications for the potential association between serum magnesium levels and insulin resistance in overweight children.

Low serum magnesium levels in overweight individuals have been previously linked to insulin resistance, a precursor to type 2 diabetes. Magnesium plays a crucial role in insulin signaling and glucose metabolism, and deficiency may contribute to impaired insulin sensitivity. The findings in this study align with existing literature, suggesting that lower serum magnesium levels in overweight children may be a contributing factor to the observed insulin resistance.

Çelik N et al.[75] found that in insulin-resistant obese individuals, serum magnesium levels were significantly lower than in controls ($p=0.014$). Another interesting observation from their study was a strong association among blood magnesium levels and BMI-SDS in the insulin-sensitive obese group, emphasizing a potential link between magnesium status and insulin resistance. Huerta MG et al.[76] reported substantially lower serum magnesium levels in obese children compared to their lean counterparts (0.748 ± 0.015 mmol/l vs. 0.801 ± 0.012 mmol/l, $p = 0.009$). Additionally, they identified a positive correlation between the quantitative insulin sensitivity check index (QUICKI) and serum magnesium, as well as an inverse relationship between serum magnesium and fasting insulin. The reduced dietary magnesium consumption in obese children further underscores the importance of magnesium in metabolic health.

In their investigation of the constituents of the metabolic syndrome in children, Jose B. et al.[77] discovered that the overweight group exhibited notably diminished levels of serum magnesium in comparison to the normal weight group. The inverse relationship between serum magnesium levels and fasting insulin, waist circumference, systolic and diastolic blood pressure, and body BMI reinforces the potential role of magnesium in mitigating metabolic disturbances. Suliburska J et al.[78] investigated blood mineral concentrations in obese adolescents and observed considerably lower concentrations of magnesium in the obese participants compared to normal weight individuals. The strong inverse correlation between serum zinc content, insulin concentration, and the HOMA-IR score further supports the notion that reduced serum magnesium levels is associated with resistance to insulin in obese children.

Guerrero-Romero and Rodriguez-Morán[79] found that individuals with metabolic syndrome had significantly lower blood magnesium concentrations compared to healthy controls (1.8 ± 0.3 mg/dL vs. 2.2 ± 0.2 mg/dL, $p < 0.00001$). The study highlighted the independent association between low blood magnesium concentrations and the presence of metabolic syndrome, with hypertension and dyslipidemia being the most strongly associated components. The study by ul Hassan SA et al.[84] reinforced the consistent trend, demonstrating considerably lower blood magnesium levels in overweight and obese children compared to normal weight controls (2.08 ± 0.211 mg/dl vs. 2.55 ± 0.155 mg/dl). The discernibly substantial inverse correlation between body mass index and serum magnesium levels further emphasizes the potential link between magnesium deficiency and the degree of obesity.

The observed difference in serum magnesium levels underscores the importance of considering magnesium status as a potential modifiable factor in interventions targeting insulin resistance in overweight children. Further investigations, such as longitudinal studies or interventional trials, are warranted to establish a more definitive causal relationship and to explore the potential benefits of magnesium supplementation in this context.

It is essential to acknowledge the limitations of this study, such as its cross-sectional nature, and the need for additional research to better understand the complex interplay between serum magnesium levels, insulin resistance, and overweight status in paediatric populations.

CONCLUSION

This study revealed a significant association between serum magnesium levels and overweight status in children. The analysis demonstrated that overweight children had markedly lower mean serum magnesium levels compared to the control group. This finding suggests a potential link between low serum magnesium and the presence of excess body weight in children.

Significant inquiries are prompted by the observed correlation regarding the function of magnesium in relation to metabolic health and insulin resistance in pediatric populations. While the precise mechanisms underlying this relationship warrant further investigation, these results highlight the potential significance of magnesium in the context of childhood obesity.

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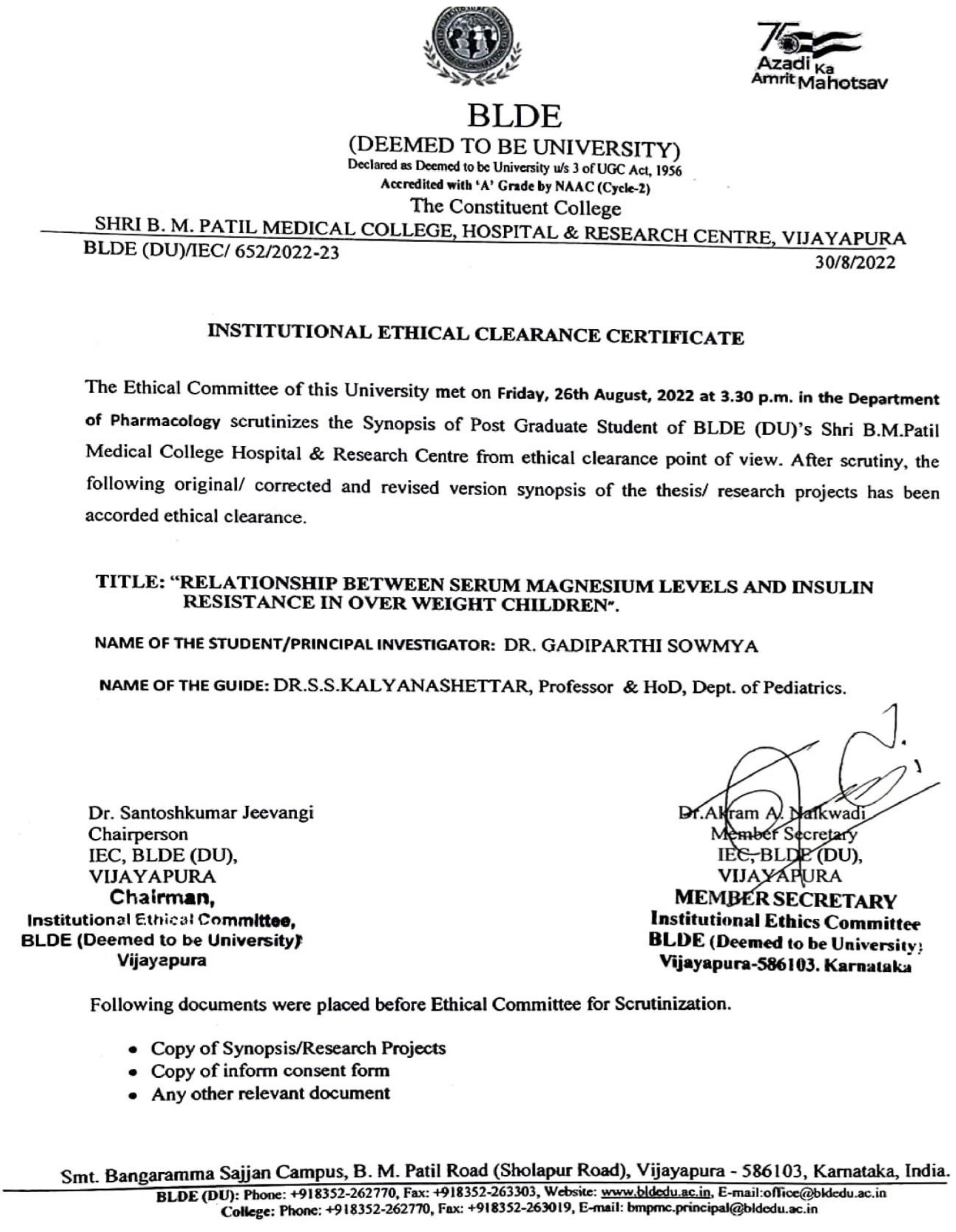
ANNEXURE - I



Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 652/2022-23

30/8/2022

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Friday, 26th August, 2022 at 3.30 p.m. in the Department of Pharmacology** scrutinizes the Synopsis of Post Graduate Student of BLDE (DU)'s Shri B.M.Patil Medical College Hospital & Research Centre from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "RELATIONSHIP BETWEEN SERUM MAGNESIUM LEVELS AND INSULIN RESISTANCE IN OVER WEIGHT CHILDREN".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR. GADIPARTHI SOWMYA

NAME OF THE GUIDE: DR.S.S.KALYANASHETTAR, Professor & HoD, Dept. of Pediatrics.

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA
Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA
MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

Smt. Bangaramma Sajjan Campus, B. M. Patil Road (Sholapur Road), Vijayapura - 586103, Karnataka, India.
BLDE (DU): Phone: +918352-262770, Fax: +918352-263303, Website: www.bldedu.ac.in, E-mail:office@bldedu.ac.in
College: Phone: +918352-262770, Fax: +918352-263019, E-mail: bmpmc.principal@bldedu.ac.in

ANNEXURE – II

RESEARCH INFORMED CONSENT FORM

BLDEA'S SHRI.B.M.PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA, KARNATAKA – 586103.

TITLE OF THE PROJECT

"RELATIONSHIP BETWEEN SERUM MAGNESIUM LEVELS AND INSULIN RESISTANCE IN OVERWEIGHT CHILDREN"

GUIDE: DR S.S. KALYANSHETTAR
PROFESSOR
DEPARTMENT OF PEDIATRICS

PG STUDENT: Dr. GADIPARTHI SOWMYA

PURPOSE OF RESEARCH:

I have been informed that the purpose of this study is to assess the relationship between serum magnesium levels and insulin resistance in overweight children.

PROCEDURE:

I understand that after having obtained a detailed clinical history and thorough clinical examination and laboratory investigations, a final follow up of the serum magnesium levels and insulin resistance and its outcome is planned.

RISK AND DISCOMFORTS:

I understand that I may experience some pain and discomforts during the examination or my treatment. This is mainly the result of my condition and the procedure of this study are not expected to exaggerate these feelings, which are associated with the usual course of treatment.

BENEFITS:

I understand that my participation in this study will have no direct benefit to me other than the potential benefit of the research and education.

CONFIDENTIALITY:

I understand that the medical information produced by the study will become a part of the hospital record and will be subjected to confidentiality and privacy regulations. Information of a sensitive personal nature will not be part of medical records but will be stored in the investigations research file.

If the data is used for publication, the identity will not be revealed; other identifiers, such as photographs, will be used only with special permission. I understand that I may see the photograph before giving my permission.

REQUEST FOR MORE INFORMATION:

I understand that I may ask for more information about the study anytime. Dr. Gadiparthi Sowmya at the Department of Pediatrics will be available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the study that might influence my child’s continued participation. A copy of this consent form will be given to me to keep for careful reading.

REFUSAL OR WITHDRAWAL OF PARTICIPATION:

I understand that my child's participation is voluntary, and I may refuse to participate or withdraw consent and discontinue participation in the study at any time without prejudice. I also understand that Dr. Gadiparthi Sowmya may terminate my participation in the study after she has explained the reasons for doing so.

INJURY STATEMENT:

I understand that in the unlikely event of injury to my child resulting directly from my participation in this study, if such injury were reported promptly, the appropriate treatment would be available to the child. However, no further compensation would be provided by the hospital. I understand that by my agreement to participate in this study and not waiving any of my legal rights.

I have explained to ______________________________________the purpose of the research, the procedures required and the possible risks to the best of my ability.

Dr. GADIPARTHI SOWMYA **Date:**
(Investigator)

PARENTS / GUARDIAN CONSENT STATEMENT:

We confirm that Dr. Gadiparthi Sowmya is conducting a study on the "**Relationship between serum magnesium levels and insulin resistance in overweight children."** In Shri B.M. Patel Medical College Hospital, Vijayapura, Karnataka. Dr. Gadiparthi Sowmya has explained the purpose of the research and the study procedure. We are willing to give as much information as required for the study and consent for interventions and the possible discomforts and benefits. We have explained all the above in detail in our language, and we understand the same. Therefore, we agree to consent to our child's participation as a subject in this research project.

_______________________________ _____________________________

(Parents / Guardian) **(Witness to signature)**
Date: **Date:**

ANNEXURE III

PROFORMA

Name:

OP no:

DEMOGRAPHIC CHARACTERISTICS

Age:

Sex:

HISTORY:

Duration of obesity:

a) In years

b) Cat: 1) < 2 years 2) 2-5 years 3) >5 years

Family history

a) Hypertension –Yes/No If Yes, parent/sibling/grandparents

b) Diabetes – Yes/No If Yes, parent /sibling/grandparents

c) Obesity - Yes/No If Yes, parent / sibling / grandparents

Diet history:

Drug history:

ANTHROPOMETRY:

Height in cm:

Weight in kg:

B.M.I. : a) Actual :

b) Category : 1) <23 adult equivalent 2) 23-27 adult equivalent 3) >27 adult equivalent.

c) Category : 1) Obesity 2) Overweight 3) Normal

CLINICAL EXAMINATION

Blood pressure:

a) Systolic -
b) Diastolic -

INVESTIGATIONS

a) Serum triglyceride a) value -

b) Total cholesterol a) value -

c) HDL cholesterol a) value -

d) LDL cholesterol a) value -

e) Serum calcium a) value -

f) Serum sodium a) value -

g) Serum Magnesium a) value -

h) Fasting insulin a) value -

i) Fasting glucose a) value -

j) Insulin resistance a) HOMA IR
b) QUICKI

BIO – DATA OF GUIDE

Name: DR. S.S KALYANSHETTAR

Date of Birth: 17/1/1974

Education: M.B.B.S., MD (PEDIATRICS)

Present Designation: Professor

Dept of Pediatrics B.L.D. E (Deemed to be University)

Shri. B.M. Patil Medical College, Vijayapura, Karnataka.

KMC Registration No: 45576

Work experience: 16 years

Membership: Indian Academy of Pediatrics

BIO – DATA OF CANDIDATE

Name: Dr. GADIPARTHI SOWMYA

Date of Birth: 26/08/1997

Age: 25 years

Qualification: MBBS

Registration No: 148633

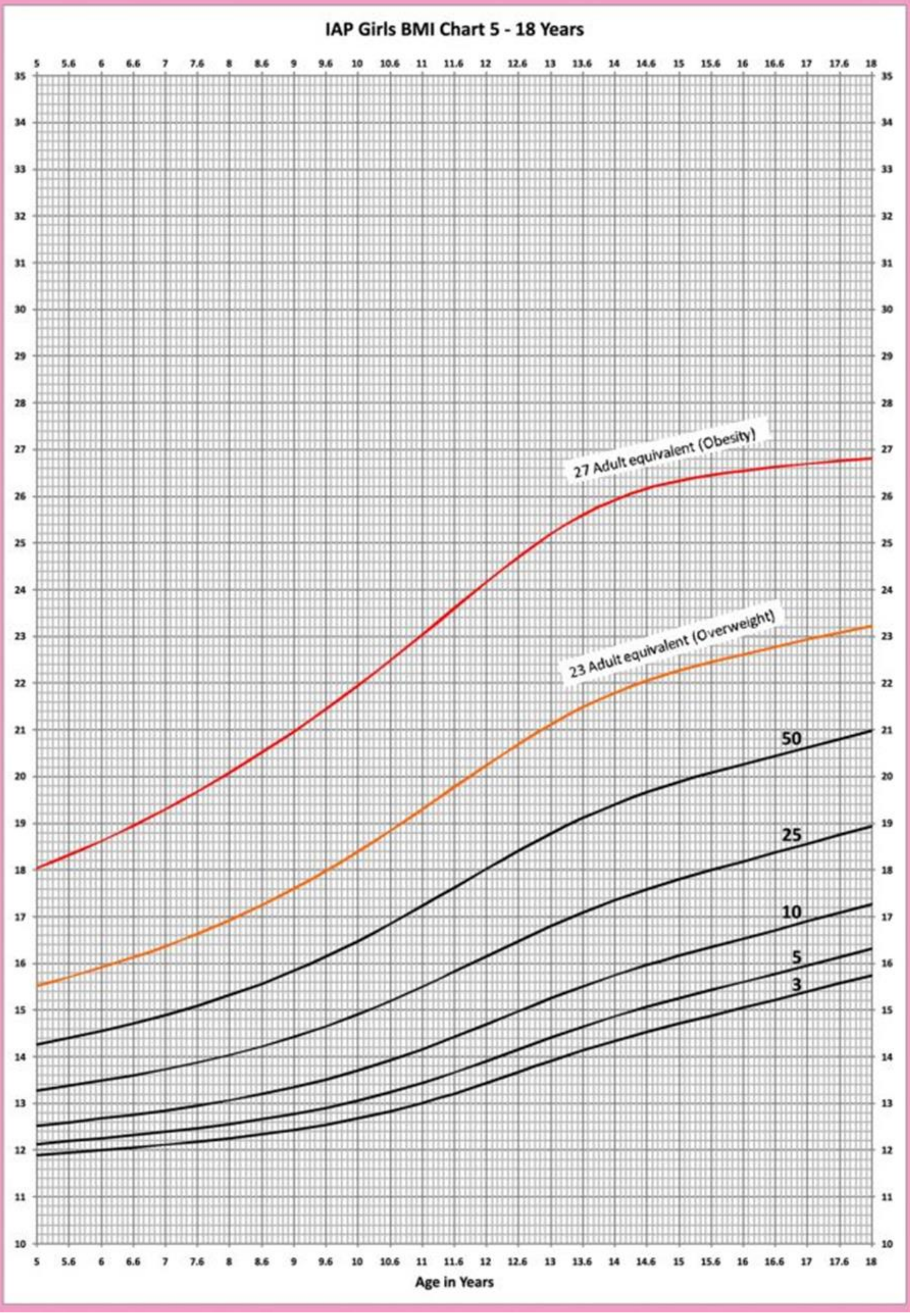
Designation: Post-graduate student,
Department of Pediatrics.

Address: NRI PG Hostel,
Shri BM Patil Medical College Hospital,
Vijayapura, Karnataka-586103.

5 to 18 Years : IAP Girls Body Mass Index Charts

Name ________________________________

DOB ________________________________

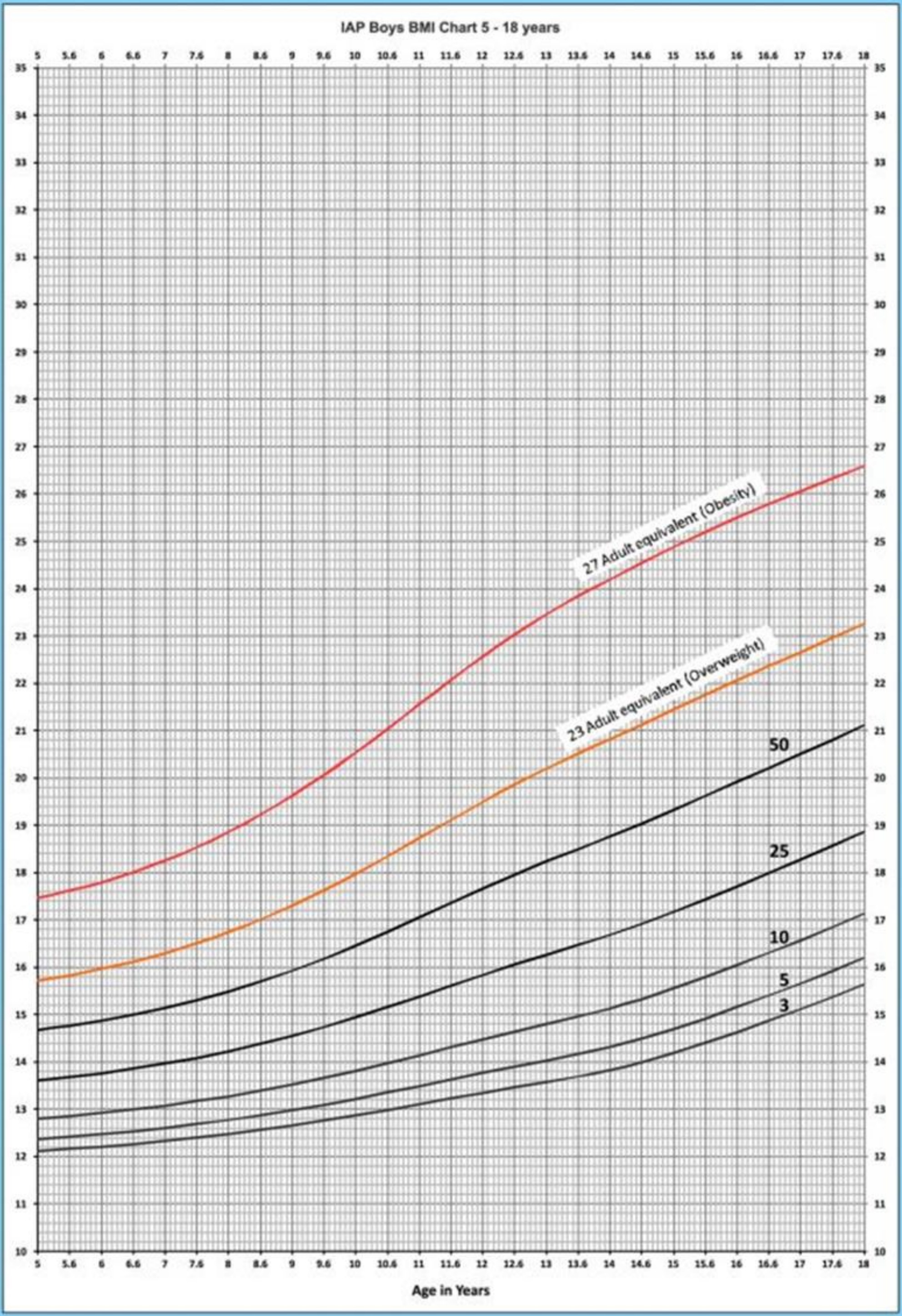


Revised IAP growth charts for height, weight & body mass index for 5 to 18 year old Indian children.
V. Khadilkar et al. from Indian Academy of Pediatrics Growth Chart Committee Indian Pediatrics. Jan 2015, volume 52

5 to 18 Years : IAP Boys Body Mass Index Charts

Name ______________________________

DOB ______________________________



Revised IAP growth charts for height, weight & body mass index for 5 to 18 year old indian children.
V. Khadilkar et al. from Indian Academy of Pediatrics Growth Chart Committee Indian Pediatrics. Jan 2015, volume 52

ANNEXURE IV

MASTER CHART

S No	Case/Control	Age	Age in months	Gender	Height	Height(in	Ht (m2)	weight	BMI	ation of ob	Percentage body fat	HbA1c	mily H/O obesi	mily h/o diabe	dy h/o hypertn	SBP	DBP	Cholesterol	Triglycerides	LDL	HDL	Serum magnesium	Serum calcium	Serum sodium	Fasting glucose	Fasting insulin	HOMA	QUICKI
1	1	12	144	1	140	1.4	1.96	70.1	35.75	3.00	40.80	5.32	1.00	1.00	2.00	103.00	65.00	175.00	148.36	124.00	22.00	0.36	10.10	143.82	4.10	25.00	6.56	0.3061
2	1	14	168	1	153	1.53	2.3409	89.7	38.32	1.00	46.08	4.91	1.00	2.00	1.00	99.00	64.00	188.00	169.20	122.00	24.00	0.47	11.00	144.61	4.68	19.00	3.95	0.3120
3	1	14	168	1	147	1.47	2.1609	70.6	32.66	3.00	43.11	5.07	2.00	1.00	1.00	88.00	60.00	176.00	138.57	125.00	22.00	0.96	10.64	140.88	4.90	15.00	3.27	0.3203
4	1	9	108	1	128	1.28	1.6384	48.4	29.56	1.00	47.04	5.33	2.00	2.00	1.00	90.00	63.00	166.00	153.23	122.00	24.00	0.44	10.64	142.57	5.73	14.00	3.57	0.3164
5	1	12	144	1	147	1.47	2.1609	74.8	34.61	2.00	36.39	5.12	1.00	2.00	2.00	94.00	60.00	171.00	137.32	123.00	24.00	0.48	10.29	139.38	4.34	25.00	4.82	0.3039
6	1	14	168	1	148	1.48	2.1904	77.6	35.41	2.00	49.58	5.06	2.00	2.00	1.00	98.00	69.00	164.00	130.87	121.00	21.00	1.09	10.81	139.92	5.42	14.00	3.37	0.3189
7	1	14	168	2	159	1.59	2.5281	84.9	33.57	2.00	38.01	5.74	1.00	2.00	1.00	89.00	65.00	192.00	137.08	127.00	23.00	0.31	9.15	136.36	5.82	27.00	6.99	0.2897
8	1	12	144	2	140	1.4	1.96	49.6	25.29	1.00	38.24	5.55	1.00	2.00	1.00	87.00	61.00	189.00	152.88	123.00	26.00	0.68	9.80	142.50	5.12	14.00	3.19	0.3214
9	1	10	120	2	135	1.35	1.8225	56.0	30.75	1.00	41.65	4.55	2.00	1.00	2.00	85.00	69.00	182.00	137.78	123.00	30.00	1.59	9.14	142.29	4.81	25.00	4.45	0.3071
10	1	10	120	2	133	1.33	1.7689	44.4	25.08	1.00	47.13	5.42	1.00	2.00	1.00	104.00	66.00	179.00	150.97	123.00	20.00	0.68	10.26	141.57	5.35	18.00	4.28	0.3087
11	1	12	144	2	143	1.43	2.0449	51.2	25.04	3.00	36.72	4.81	2.00	2.00	2.00	95.00	66.00	190.00	176.56	121.00	27.00	2.00	9.93	137.36	5.12	23.00	5.23	0.3006
12	1	16	192	2	153	1.53	2.3409	86.6	36.99	3.00	41.86	4.82	2.00	1.00	1.00	106.00	66.00	178.00	153.84	124.00	24.00	1.76	10.81	143.55	4.84	18.00	3.87	0.3129
13	1	16	192	1	154	1.54	2.3716	68.9	29.07	3.00	48.91	5.96	2.00	2.00	2.00	98.00	62.00	176.00	177.31	123.00	30.00	0.62	9.76	143.53	4.92	21.00	4.60	0.3058
14	1	13	156	2	146	1.46	2.1316	59.3	27.84	3.00	36.31	4.48	2.00	1.00	1.00	103.00	62.00	176.00	164.03	129.00	21.00	1.44	9.36	139.43	5.84	22.00	4.90	0.3030
15	1	9	108	1	129	1.29	1.6641	47.9	28.78	3.00	43.91	5.45	1.00	1.00	2.00	89.00	70.00	166.00	140.77	130.00	23.00	0.53	10.26	137.39	4.27	19.00	3.44	0.3181
16	1	12	144	2	147	1.47	2.1609	67.2	31.08	1.00	46.85	5.21	2.00	2.00	2.00	110.00	62.00	171.00	163.67	125.00	28.00	1.54	10.28	141.66	4.69	24.00	5.00	0.3024
17	1	16	192	2	158	1.58	2.4964	69.3	27.75	2.00	38.10	4.73	2.00	2.00	1.00	108.00	66.00	195.00	141.02	123.00	28.00	0.75	9.81	144.71	5.54	13.00	3.20	0.3212
18	1	13	156	2	145	1.45	2.1025	77.1	36.68	3.00	45.65	4.47	1.00	2.00	1.00	88.00	64.00	198.00	143.48	125.00	21.00	1.94	10.21	139.96	4.08	16.00	2.90	0.3256
19	1	9	108	2	128	1.28	1.6384	53.7	32.75	1.00	48.76	4.06	1.00	2.00	1.00	94.00	60.00	170.00	153.43	125.00	22.00	0.85	10.66	138.89	4.68	15.00	3.12	0.3224
20	1	13	156	1	147	1.47	2.1609	56.5	26.12	2.00	37.81	5.57	2.00	1.00	1.00	98.00	66.00	168.00	154.64	127.00	26.00	0.38	9.62	142.08	5.19	15.00	3.46	0.3178
21	1	8	96	1	135	1.35	1.8225	70.6	38.75	1.00	46.11	5.84	1.00	2.00	1.00	105.00	62.00	172.00	164.06	121.00	26.00	1.65	10.84	143.76	5.44	13.00	3.14	0.3221
22	1	14	168	2	148	1.48	2.1904	62.5	28.54	1.00	43.29	4.70	1.00	2.00	1.00	102.00	69.00	195.00	176.83	130.00	26.00	0.09	9.03	144.57	5.01	16.00	3.57	0.3165
23	1	9	108	2	138	1.38	1.9044	63.1	33.12	3.00	47.20	4.77	2.00	2.00	1.00	93.00	70.00	171.00	168.62	124.00	28.00	0.64	9.04	144.84	5.00	26.00	5.78	0.2968
24	1	9	108	1	133	1.33	1.7689	67.5	38.18	3.00	43.04	4.17	1.00	2.00	1.00	90.00	61.00	161.00	135.96	127.00	20.00	0.42	10.49	138.47	5.79	18.00	4.64	0.3054
25	1	9	108	1	128	1.28	1.6384	42.1	25.72	3.00	41.38	4.30	1.00	2.00	1.00	106.00	67.00	196.00	137.15	122.00	28.00	1.91	10.47	142.14	4.71	24.00	5.02	0.3022
26	1	11	132	1	145	1.45	2.1025	69.1	32.87	3.00	36.15	5.27	2.00	2.00	1.00	103.00	66.00	169.00	141.68	120.00	28.00	1.40	10.78	138.96	4.33	18.00	3.46	0.3177
27	1	15	180	2	153	1.53	2.3409	81.7	34.91	2.00	39.98	6.00	2.00	1.00	2.00	101.00	66.00	160.00	141.42	127.00	24.00	0.79	9.60	142.00	4.51	22.00	4.41	0.3075
28	1	11	132	2	142	1.42	2.0164	48.5	24.06	1.00	47.89	4.64	2.00	1.00	2.00	103.00	61.00	198.00	173.70	127.00	24.00	1.09	10.87	137.10	5.79	20.00	5.14	0.3013
29	1	9	108	2	138	1.38	1.9044	67.5	35.44	3.00	43.43	4.13	1.00	2.00	1.00	95.00	61.00	168.00	165.32	128.00	23.00	0.54	9.64	136.64	5.12	19.00	4.32	0.3083
30	1	14	168	1	148	1.48	2.1904	74.3	33.94	3.00	44.14	5.71	1.00	1.00	2.00	89.00	62.00	183.00	162.64	123.00	26.00	1.39	10.50	138.84	4.65	14.00	2.89	0.3258
31	1	11	132	2	147	1.47	2.1609	78.7	36.41	3.00	49.77	5.42	1.00	2.00	2.00	110.00	63.00	177.00	164.29	122.00	24.00	1.84	10.20	141.96	4.06	24.00	4.33	0.3082
32	1	8	96	1	128	1.28	1.6384	48.5	29.58	1.00	38.16	4.36	2.00	2.00	1.00	100.00	67.00	176.00	137.72	128.00	29.00	1.31	9.78	145.00	5.17	20.00	4.60	0.3058
33	1	14	168	1	157	1.57	2.4649	86.9	35.25	2.00	43.61	4.71	2.00	2.00	2.00	104.00	62.00	198.00	159.76	126.00	25.00	0.71	10.73	143.31	5.17	18.00	4.14	0.3101
34	1	14	168	2	155	1.55	2.4025	84.9	35.32	3.00	49.98	4.90	1.00	1.00	2.00	94.00	63.00	188.00	165.26	122.00	21.00	1.71	10.02	140.19	5.52	25.00	6.13	0.2945
35	1	8	96	1	131	1.31	1.7161	50.5	29.43	1.00	45.44	5.11	2.00	2.00	2.00	106.00	63.00	160.00	166.15	126.00	24.00	1.04	9.42	144.95	5.51	13.00	3.19	0.3214
36	1	14	168	1	159	1.59	2.5281	78.3	30.95	2.00	41.21	5.64	2.00	1.00	2.00	100.00	69.00	177.00	174.46	129.00	25.00	0.49	10.06	144.00	5.26	22.00	5.15	0.3013
37	1	8	96	2	135	1.35	1.8225	46.1	25.31	3.00	50.84	5.33	2.00	1.00	1.00	105.00	70.00	175.00	137.09	127.00	20.00	0.86	9.28	138.31	5.72	17.00	4.32	0.3083
38	1	9	108	1	131	1.31	1.7161	49.9	29.08	1.00	45.27	5.32	1.00	2.00	2.00	86.00	66.00	176.00	167.32	125.00	24.00	0.48	9.42	140.53	4.57	22.00	4.47	0.3069
39	1	12	144	2	143	1.43	2.0449	58.0	28.37	2.00	47.75	4.84	2.00	2.00	1.00	104.00	60.00	180.00	130.23	125.00	20.00	1.18	10.67	136.38	4.03	13.00	2.33	0.3364
40	1	12	144	2	147	1.47	2.1609	61.8	28.58	3.00	38.45	4.94	2.00	2.00	1.00	85.00	67.00	164.00	146.11	120.00	21.00	1.73	9.52	139.45	4.20	27.00	5.04	0.3021
41	1	8	96	1	136	1.36	1.8496	46.0	24.90	1.00	45.81	4.25	2.00	2.00	2.00	97.00	65.00	170.00	151.19	128.00	25.00	1.56	9.98	144.16	4.02	27.00	4.83	0.3038
42	1	14	168	1	151	1.51	2.2801	76.0	33.32	2.00	43.91	4.37	2.00	1.00	2.00	95.00	68.00	183.00	145.88	122.00	29.00	0.66	9.75	136.19	5.94	15.00	3.96	0.3120
43	1	8	96	1	137	1.37	1.8769	55.0	29.30	3.00	47.19	4.09	2.00	1.00	1.00	105.00	63.00	180.00	137.38	121.00	25.00	0.82	9.26	140.48	5.58	23.00	5.70	0.2973
44	1	14	168	2	154	1.54	2.3716	61.6	25.96	2.00	48.20	4.50	2.00	2.00	1.00	91.00	68.00	195.00	165.63	126.00	29.00	1.75	10.91	136.16	5.25	13.00	3.04	0.3236
45	1	11	132	2	144	1.44	2.0736	60.5	29.18	3.00	37.18	5.89	2.00	1.00	2.00	98.00	62.00	188.00	175.52	121.00	22.00	1.22	9.98	137.77	5.84	26.00	6.75	0.2909
46	1	15	180	1	155	1.55	2.4025	76.3	31.77	1.00	39.33	4.90	1.00	2.00	1.00	87.00	62.00	196.00	163.01	130.00	29.00	1.32	9.98	136.38	4.52	15.00	3.01	0.3239
47	1	9	108	1	132	1.32	1.7424	63.1	36.20	2.00	44.78	4.60	1.00	2.00	2.00	105.00	67.00	199.00	136.23	128.00	23.00	1.39	10.16	141.08	5.83	21.00	5.44	0.2991
48	1	14	168	1	156	1.56	2.4336	87.6	36.01	1.00	40.18	4.19	1.00	2.00	2.00	87.00	61.00	162.00	144.63	127.00	30.00	1.71	10.18	139.36	5.64	27.00	6.77	0.2909
49	1	12	144	1	145	1.45	2.1025	70.6	33.59	1.00	46.14	5.18	2.00	2.00	1.00	102.00	61.00	167.00	152.09	123.00	20.00	0.86	10.09	144.55	4.73	19.00	4.00	0.3116
50	1	9	108	2	128	1.28	1.6384	60.3	36.79	3.00	43.52	5.74	1.00	2.00	1.00	108.00	67.00	199.00	175.26	129.00	24.00	1.99	9.14	137.62	5.51	17.00	4.16	0.3099
51	1	11	132	2	146	1.46	2.1316	82.6	38.76	2.00	46.14	4.37	1.00	2.00	2.00	86.00	68.00	181.00	169.05	126.00	30.00	0.42	9.64	143.17	5.07	26.00	5.86	0.2962
52	1	10	120	2	131	1.31	1.7161	57.0	33.19	1.00	39.59	4.91	1.00	1.00	2.00	89.00	69.00	191.00	130.18	126.00	26.00	1.40	10.37	141.18	5.21	17.00	3.94	0.3122
53	1	13	156	1	139	1.39	1.9321	48.9	25.34	3.00	47.50	5.87	2.00	1.00	1.00	102.00	69.00	188.00	161.10	124.00	20.00	0.42	9.24	144.87	5.63	24.00	6.01	0.2953
54	1	11	132	2	143	1.43	2.0449	50.3	24.61	1.00	42.73	4.83	1.00	2.00	1.00	86.00	61.00	192.00	144.73	125.00	24.00	0.37	10.45	143.74	5.69	18.00	4.55	0.3062
55	1	16	192	1	157	1.57	2.4649	68.3	27.70	3.00	36.52	5.25	2.00	1.00	1.00	110.00	60.00	198.00	131.26	129.00	28.00	0.54	10.99	139.82	5.64	13.00	3.26	0.3204
56	2	13	156	1	142	1.42	2.0164	41.5	20.57		20.49	4.05	2.00	1.00	1.00	106.00	68.00	111.00	68.46	104.00	26.00	2.09	9.10	144.37	5.71	5.00	1.27	0.3688
57	2	16	192	2	156	1.56	2.4336	43.8	17.99		17.93	5.97	2.00	2.00	1.00	109.00	61.00	139.00	74.07	87.00	24.00	1.22	10.50	136.10	4.81	8.00	1.71	0.3520
58	2	11	132	2	140	1.4	1.96	32.0	16.32		18.29	4.40	1.00	1.00	1.00	101.00	67.00	116.00	106.36	87.00	22.00	1.31	9.68	142.84	4.80	10.00	1.91	0.3461
59	2	14	168	1	150	1.5	2.25	41.3	18.36		16.31	4.13	1.00	1.00	2.00	102.00	61.00	133.00	118.16	62.00	33.00	1.31	10.80	136.99	5.42	9.00	2.17	0.3397
60	2	14	168	1	153	1.53	2.3409	40.4	17.24		18.94	5.96	2.00	1.00	2.00	97.00	64.00	133.00	78.93	81.00	47.00	1.28	10.46	139.25	5.89	10.00	2.62	0.3305
61	2	9	108	2	131	1.31	1.7161	36.1	21.03		16.94	5.00	1.00	2.00	1.00	109.00	67.00	150.00	97.48	88.00	25.00	2.25	10.14	139.52	4.79	10.00	2.13	0.3406
62	2	14	168	2	156	1.56	2.4336	38.6	15.85		19.91	4.30	1.00	2.00	2.00	94.00	63.00	132.00	113.10	110.00	25.00	1.12	9.41	141.20	5.75	10.00	2.56	0.3316
63	2	12	144	1	144	1.44	2.0736	32.6	15.72		17.71	5.35	2.00	1.00	2.00	93.00	63.00	121.00	89.91	73.00	37.00	2.74	10.86	142.07	5.19	6.00	1.38	0.3638
64	2	13	156	1	147	1.47	2.1609	31.5	14.58		27.04	5.85	2.00	1.00	2.00	110.00	64.00	135.00	74.54	84.00	46.00	1.48	10.89	142.56	5.54	7.00	1.72	0.3516
65	2	8	96	2	130	1.3	1.69	34.5	20.44		23.47	5.12	1.00	2.00	1.00	105.00	62.00	130.00	68.39	64.00	35.00	2.00	9.14	143.60	5.23	10.00	2.32	0.3363
66	2	12	144	1	145	1.45	2.1025	30.6	14.55		25.63	4.34	1.00	2.00	1.00	93.00	63.00	131.00	109.15	70.00	33.00	2.36	9.64	140.60	4.56	10.00	2.02	0.3431
67	2	11	132	1	139	1.39	1.9321	42.0	21.76		26.13	4.94	2.00	2.00	2.00	92.00	66.00	131.00	75.29	73.00	29.00	2.88	10.67	137.57	4.38	8.00	1.56	0.3571
68	2	15	180	1	156	1.56	2.4336	39.5	16.25		23.41	4.25	1.00	2.00	2.00	103.00	68.00	131.00	79.05	80.00	37.00	1.31	9.21	136.05	4.47	10.00	1.99	0.3441
69	2	14	168	2	157	1.57	2.4649	41.2	16.71		22.22	4.36	1.00	2.00	1.00	90.00	67.00	134.00	66.22	102.00	24.00	1.10	10.30	142.09	4.77	5.00	1.06	0.3798
70	2	14	168	2	159	1.59	2.5281	53.9	21.33		22.37	5.20	2.00	2.00	1.00	96.00	69.00	118.00	68.49	109.00	41.00	2.76	10.91	143.28	5.40	5.00	1.20	0.3721
71	2	16	192	1	154	1.54	2.3716	42.9	18.09		21.66	5.57	1.00	2.00	1.00	110.00	66.00	133.00	83.64	90.00	36.00	2.13	9.83	138.93	5.71	6.00	1.52	0.3584
72	2	12	144	2	140	1.4	1.96	29.0	14.81		16.35	4.60	2.00	1.00	2.00	99.00	69.00	149.00	78.69	86.00	34.00	2.55	10.59	136.08	4.78	10.00	2.11	0.3411
73	2	13	156	1	146	1.46	2.1316	41.0	19.22		22.63	4.43	2.00	2.00	2.00	96.00	62.00	149.00	114.56	75.00	35.00	1.11	10.25	140.59	5.99	5.00	1.33	0.3660
74	2	8	96	2	135	1.35	1.8225	29.9	16.42		24.66	5.13	1.00	2.00	2.00	98.00	66.00	140.00	97.90	83.00	39.00	2.29	10.97	144.81	4.50	7.00	1.40	0.3631
75	2	13	156	1	142	1.42	2.0164	33.3	16.51		24.83	5.50	2.00	2.00	2.00	91.00	61.00	134.00	117.62	76.00	37.00	1.30	10.24	140.64	4.58	8.00	1.63	0.3546
76	2	8	96	2	135	1.35	1.8225	35.7	19.61		26.01	5.75	2.00	2.00	2.00	108.00	70.00	130.00	109.11	92.00	41.00	2.25	10.30	137.44	4.61	9.00	1.84	0.3480
77	2	16	192	2	151	1.51	2.2801	34.0	14.90		15.97	4.01	1.00	2.00	1.00	93.00	60.00	116.00	117.42	74.00	25.00	2.56	10.18	136.96	4.36	8.00	1.55	0.3573
78	2	15	180	1	158	1.58	2.4964	54.2	21.72		27.97	4.37	1.00	2.00	2.00	99.00	64.00	144.00	71.49	77.00	27.00	1.47	9.08	144.88	5.24	10.00	2.33	0.3362
79	2	11	132	2	141	1.41	1.9881	38.5	19.38		16.20	4.70	1.00	2.00	2.00	92.00	62.00	113.00	102.72	65.00	25.00	1.92	10.64	136.10	4.43	6.00	1.18	0.3731
80	2	10	120	2	133	1.33	1.7689	33.7	19.06		23.92	4.11	1.00	1.00	2.00	97.00	63.00	155.00	74.36	109.00	35.00	1.57	9.67	143.29	5.17	7.00	1.61	0.3553
81	2	11	132	2	139	1.39	1.9321	29.6	15.32		24.86	5.12	2.00	2.00	1.00	109.00	61.00	117.00	113.71	89.00	29.00	1.15	10.14	139.75	5.10	5.00	1.13	0.3756
82	2	9	108	2	128	1.28	1.6384	30.4	18.54		20.89	6.00	2.00	1.00	1.00	104.00	68.00	120.00	118.57	99.00	33.00	1.50	9.52	138.17	4.31	6.00	1.15	0.3748
83	2	15	180	1	159	1.59	2.5281	55.3	21.87		25.36	5.09	1.00	2.00	1.00	108.00	69.00	118.00	79.11	61.00	22.00	2.56	10.16	139.65	5.65	10.00	2.51	0.3324
84	2	14	168	1	151	1.51	2.2801	41.8	18.35		19.25	5.27	1.00	1.00	2.00	108.00	62.00	149.00	106.92	104.00	43.00	2.11	9.95	137.60	4.10	9.00	1.64	0.3543
85	2	12	144	1	143	1.43	2.0449	32.3	15.80		15.24	5.55	2.00	1.00	1.00	95.00	67.00	143.00	71.36	101.00	23.00	2.21	9.33	139.05	4.33	8.00	1.54	0.3577
86	2	9	108	1	132	1.32	1.7424	28.5	16.38		22.84	4.87	1.00	2.00	1.00	90.00	68.00	150.00	109.83	98.00	34.00	2.94	10.38	141.96	5.72	7.00	1.78	0.3499
87	2	8	96	1	137	1.37	1.8769	30.6	16.31		17.94	5.58	1.00	2.00	2.00	104.00	63.00	141.00	115.11	81.00	44.00	1.85	9.82	144.36	4.91	8.00	1.75	0.3509
88	2	8	96	2	137	1.37	1.8769	28.5	15.19		22.39	4.70	2.00	2.00	2.00	104.00	68.00	138.00	101.44	82.00	35.00	1.92	10.78	137.48	4.47	7.00	1.39	0.3635
89	2	10	120	1	138	1.38	1.9044	41.2	21.63		26.89	5.11	2.00	1.00	1.00	99.00	60.00	141.00	95.12	76.00	21.00	1.46	9.21	142.78	4.81	10.00	2.14	0.3404
90	2	15	180	2	159	1.59	2.5281	38.3	15.13		22.14	5.27	1.00	2.00	1.00	90.00	70.00	137.00	110.28	98.00	21.00	2.84	9.07	141.28	4.88	10.00	2.17	0.3397
91	2	16	192	1	153	1.53	2.3409	46.7	19.94		17.96	4.20	2.00	1.00	1.00	105.00	67.00	155.00	103.13	91.00	21.00	2.07	10.43	137.21	4.94	5.00	1.10	0.3776
92	2	14	168	2	150	1.5	2.25	43.0	19.11		22.76	5.82	1.00	2.00	2.00	109.00	66.00	116.00	97.72	64.00	25.00	1.53	10.82	143.20	5.72	6.00	1.53	0.3582
93	2	16	192	2	155	1.55	2.4025	35.9	14.94		16.21	4.07	2.00	1.00	2.00	91.00	67.00	152.00	93.75	66.00	21.00	1.59	10.65	143.70	5.63	7.00	1.75	0.3507
94	2	9	108	1	134	1.34	1.7956	31.6	17.61		18.67	5.56	2.00	2.00	2.00	95.00	64.00	115.00	111.69	107.00	40.00	1.05	10.90	141.79	5.53	10.00	2.46	0.3335
95	2	16	192	2	156	1.56	2.4336	48.5	19.95		16.48	4.15	2.00	2.00	1.00	98.00	67.00	122.00	107.27	64.00	40.00	2.05	9.14	144.98	4.29	9.00	1.72	0.3518
96	2	9	108	2	132	1.32	1.7424	29.9	17.16		26.66	5.76	1.00	1.00	1.00	104.00	68.00	126.00	73.70	109.00	23.00	1.81	10.38	137.22	4.48	8.00	1.59	0.3559
97	2	15	180	1	156	1.56	2.4336	44.6	18.34		17.53	4.59	1.00	2.00	2.00	103.00	66.00	133.00	95.87	86.00	23.00	2.03	10.86	138.02	5.18	9.00	2.07	0.3420
98	2	10	120	1	134	1.34	1.7956	35.9	20.01		17.33	5.35	1.00	1.00	1.00	91.00	61.00	153.00	90.56	89.00	27.00	1.83	9.46	140.45	5.54	9.00	2.21	0.3386
99	2	11	132	1	140	1.4	1.96	31.8	16.21		22.98	5.64	1.00	2.00	1.00	105.00	60.00	136.00	110.64	75.00	28.00	1.41	9.65	136.82	5.23	10.00	2.33	0.3362
100	2	11	132	2	140	1.4	1.96	42.5	21.70		24.85	4.80	1.00	1.00	2.00	110.00	68.00	122.00	88.57	109.00	42.00	2.42	10.92	143.40	5.78	6.00	1.54	0.3577
101	2	14	168	2	147	1.47	2.1609	30.6	14.17		21.62	4.62	1.00	1.00	2.00	93.00	69.00	125.00	84.43	77.00	36.00	2.93	10.74	144.13	5.14	6.00	1.37	0.3644
102	2	13	156	1	145	1.45	2.1025	40.0	19.03		24.60	4.36	1.00	1.00	1.00	91.00	60.00	116.00	117.48	98.00	23.00	1.59	10.02	140.91	4.10	8.00	1.46	0.3608
103	2	11	132	2	147	1.47	2.1609	40.7	18.83		20.55	4.53	2.00	2.00	1.00	95.00	70.00	144.00	88.98	80.00	24.00	1.37	10.66	141.34	4.63	9.00	1.85	0.3478
104	2	13	156	1	146	1.46	2.1316	45.1	21.14		17.57	4.31	1.00	2.00	2.00	96.00	68.00	138.00	87.70	95.00	46.00	1.84	10.62	142.06	5.65	8.00	2.01	0.3436
105	2	15	180	2	150	1.5	2.25	38.5	17.13		26.50	5.14	2.00	1.00	1.00	96.00	68.00	133.00	74.86	86.00	46.00	1.02	9.64	138.09	5.84	9.00	2.34	0.3360
106	2	15	180	1	152	1.52	2.3104	48.1	20.84		22.89	4.89	1.00	2.00	1.00	98.00	69.00	130.00	74.14	63.00	38.00	1.31	10.21	141.38	5.99	7.00	1.86	0.3474
107	2	12	144	1	140	1.4	1.96	35.8	18.27		19.99	5.39	2.00	1.00	2.00	107.00	65.00	144.00	73.12	88.00	41.00	2.75	9.70	140.35	4.58	6.00	1.22	0.3710
108	2	9	108	2	137	1.37	1.8769	29.1	15.50		23.64	4.38	2.00	1.00	1.00	109.00	66.00	136.00	78.14	70.00	21.00	1.17	9.33	141.07	4.32	10.00	1.92	0.3458
109	2	9	108	2	132	1.32	1.7424	32.5	18.63		26.93	4.77	2.00	2.00	2.00	100.00	61.00	122.00	108.81	99.00	32.00	1.45	9.04	139.31	5.19	8.00	1.85	0.3479
110	2	9	108	1	136	1.36	1.8496	38.6	20.87		21.05	4.14	2.00	1.00	2.00	102.00	61.00	131.00	118.87	69.00	35.00	1.82	10.80	140.37	5.54	10.00	2.46	0.3334