A DISSERTATION ON

"EFFECTS OF ZINC SUPPLEMENTATION ON GLYCEMIC CONTROL IN NEWLY DETECTED TYPE 2 DIABETES MELLITUS"

Dissertation submitted to

THE TAMILNADU

Dr.M.G.R. MEDICAL UNIVERSITY

in partial fulfilment of the requirements

for the degree of

M.D. [GENERAL MEDICINE]

BRANCH - I

E.S.I.C MEDICAL COLLEGE & PGIMSR,
K.K.NAGAR, CHENNAI-78.

APRIL -2015

CERTIFICATE OF GUIDE

This is to certify that this dissertation **"EFFECTS OF ZINC SUPPLEMENTATION ON GLYCEMIC CONTROL IN NEWLY DETECTED TYPE 2 DIABETES MELLITUS"** submitted by **Dr.ARUN KUMAR.G,** appearing for M.D.Degree Branch - I **GENERAL MEDICINE** examination in April 2015 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfilment of the regulations of the Tamilnadu Dr.M.G.R Medical University, Chennai. I forward this to the Tamilnadu Dr.M.G.R Medical University, Chennai, Tamilnadu, India.

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This is to certify that this dissertation "**EFFECTS OF ZINC SUPPLEMENTATION ON GLYCEMIC CONTROL IN NEWLY DETECTED TYPE 2 DIABETES MELLITUS ''** submitted by **Dr.ARUN KUMAR.G,** appearing for M.D. Degree Branch- I **GENERAL MEDICINE** examination in April 2015 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfilment of the regulations of the Tamilnadu Dr.M.G.R Medical University, Chennai. I forward this to the Tamilnadu Dr.M.G.R Medical University, Chennai, Tamilnadu, India.

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DECLARATION BY THE CANDIDATE

I solemnly declare that this dissertation entitled " **EFFECTS OF ZINC SUPPLEMENTATION ON GLYCEMIC CONTROL IN NEWLY DETECTED TYPE 2 DIABETES MELLITUS''** was done by me at ESIC Medical college and PGIMSR, KKNAGAR, CHENNAI during 2011-2013 under the guidance and supervision of **Prof.DR.A.R.MALATHY M.D.,** This dissertation is submitted to the Tamil Nadu Dr. M.G.R. Medical University towards the partial fulfilment of requirements for the award of M.D. Degree in GENERAL MEDICINE (Branch-I).

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I hereby declare that Tamilnadu Dr.M.G.R Medical University, Chennai, Tamilnadu, India shall have the rights to preserve, use and disseminate this Dissertation/Thesis in print or electronic format for academic/research purpose.

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ACKNOWLEDGEMENT

In the first place I would like to convey my gratitude to our Dean **Dr.SRIKUMARI DAMODARAM M.S., M.Ch (SGE)., M.A.M.S., F.A.C.S., F.I.C.S., F.M.M.C** for providing me unflinching encouragement and support.

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My sincere thanks to **all the patients** without whose co-operation this study would not have been possible.

CERTIFICATE OF APPROVAL

To

Dr. Arunkumar G.
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Dear Dr. Arunkumar G.,

The Institutional Ethics committee of ESI-PGIMSR, reviewed and discussed your application for approval of the proposal entitled **"Effects of Zinc Supplementation on Newly Detected Type II Diabetes Mellitus"** No.1/20022013.

The following members of Ethics Committee were present in the meeting held on 20.02.2013 conducted at ESI-PGIMSR, Chennai 600 078.

1.	Dr. K.S. Sekar	-	Chairperson
2.	Dr. Kamalini Sridharan Prof. & HOD. Of Anesthesia, ESI-PGIMSR	-	Member Secretary
3.	Dr. M. Kanaheswari Assoc. Prof., Dept of OBG	-	Deputy Registrar
4.	Dr. Premila	-	EC Member
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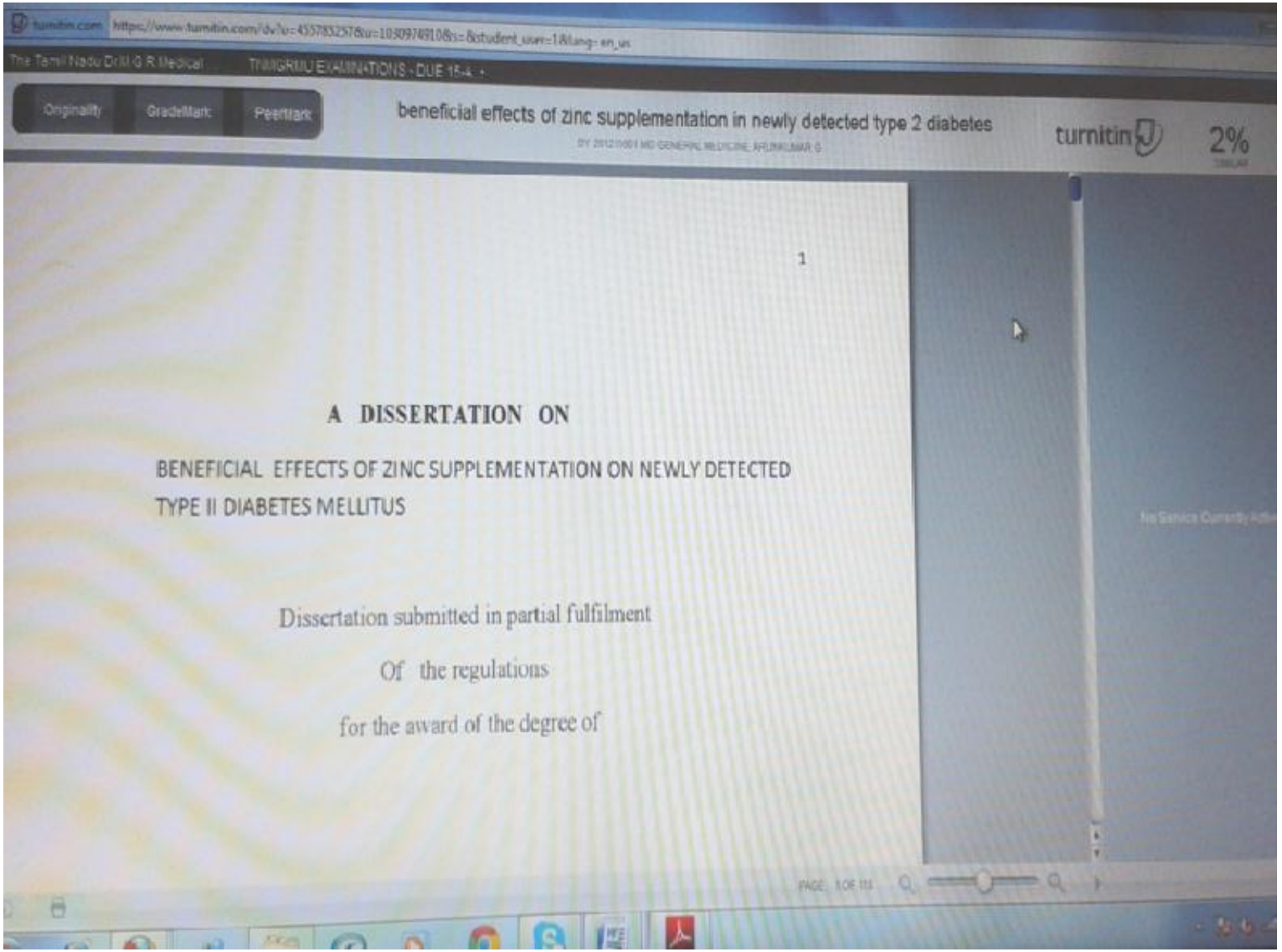
6.	Dr. C. Rajendiran	-	EC Member
7.	Dr. S. Dhanalakshmi	-	EC Member
8.	Sister Lalitha Teresa	-	EC Member
9.	Dr. A.V. Srinivasan	-	EC Member
10.	Shri K.M. Venugopal	-	Legal Advisor

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

Place : Chennai
Date : 20.02.2013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ABSTRACT

AIMS AND OBJECTIVES

1. To estimate Sr.Zinc levels at detection of Type 2 Diabetes mellitus.
2. To study the effect of Zinc supplementation on glycemic Control as evaluated by HbA1C in newly detected type 2 diabetic patients.

Secondary Objectives:

1. To study the effect of supplementation of Zinc on Lipid profile, & Body Mass Index in newly detected type 2 diabetic patients.

INCLUSION CRITERIA

1. Newly diagnosed Type 2 diabetic subjects without complications, attending ESIC PGIMSR MEDICAL OPD ,KK Nagar,Chennai-78.
2. Age $\geq$ 20.
3. Gender – both male and female.

EXCLUSION CRITERIA

1. Type-1 Diabetes,
2. Type-2 diabetics with complications
3. Diabetes in pregnancy
4. Chronic kidney disease

5. Chronic Liver Disease, Chronic Pancreatitis or IBD (Inflammatory Bowel disease)
6. Subjects on Zinc supplementation, Immunomodulators drugs, chelating drugs.

CONSENT

All patients were recruited in the study after getting consent in the consent form in vernacular language. Consent form was approved by Institutional Ethical Committee, ESI PGIMSR, KK Nagar.

METHODS

All the new patients attending the OPD with risk factors for DM or the patients referred from ESI Dispensary after urine glucose was positive or from other departments were initially selected and after getting consent regarding investigations and further inclusion in the study, patients were subjected to FBG and HBA1C. After exclusion of patients with IFG or IGT or with normal glucose levels, remaining patients of about 140 patients were subjected to Ultra sonogram abdomen to rule out chronic kidney disease, chronic liver disease, fundus examination to rule out Diabetic Retinopathy and ECG, Blood Urea Sr.Creatinine, Urine routine examination along with early morning urine microalbuminuria were done. **After completing investigations 140 patients were divided randomly into two groups according to computer generated**

random number. So each group consisted 70 patients . Patient groups are assigned as 1 and 2.

RESULTS

140 patients were included after meeting eligibility criteria in the study in two groups and followed for a period of about one year . BMI, FBG, PPBG, HBA1C, Serum Zinc Levels, Haemogram, Urine Routine analysis and microalbuminuria were done and tabulated in the worksheet and analyzed. Results are as follows:

Treatment Groups

Treatment Groups	Name of Group	Treatment	Number of Subjects
Group 1	Placebo	Placebo supplementation + OHA in newly detected type 2 diabetic patients	70
Group 2	Zinc	Zinc supplementation (50 mg/day) + OHA in newly detected type 2 diabetic patients	70

In our study Mean age of the subjects was included with placebo group is 48.17 and Zinc group is 47.27. There is no significance between the groups implying that there is about equal distribution in the Groups. Lowest age in the study is 29 years and highest age 67 years. Maximum number of patients were between the 41-50 years. There was about equal distribution of the male and

female patient about 1:1 ratio totally and in all groups. Serum Zinc levels in most of the subjects in both groups were below 75 microgm/dl before Zinc supplementation. After Zinc supplementation Serum Zinc levels were significantly increased . Statiscally this indicates that there is a true difference within the Zinc supplementation group (pre and Post intervention) in relation to HBA1c levels and the difference is significant.

In simple terms, with Zinc supplementation in newly detected type 2 diabetic patients, the fasting blood glucose levels is reduced by 22 mg/dl in comparison with placebo which reduces fasting blood sugar levels by 9.57 mg/dl with a p-value of 0.00079 according to unpaired t-test.

In simple terms, with Zinc supplementation in newly detected type 2 diabetic patients, the post prandial blood glucose levels is reduced by 45 mg/dl in comparison with placebo which reduces post prandial blood sugar levels by 16 mg/dl with a p-value of 0.0323 according to unpaired t-test.

Zinc supplementation in newly detected type 2 diabetic patients, the HBA1c levels is reduced by 0.95% in comparison with placebo which reduces HBA1c levels by 0.25% with a p-value of 0.00036 according to unpaired t-test. The reduction in HBA1c levels was meaningfully more (79%) in the Zinc supplementation group compared to the placebo group by 0.097 %.

The difference within the treatment groups (pre and Post intervention) and serum VLDL, TG, CHL, HDL, LDL levels is considered to be not statistically significant since $p > 0.05$.

BMI has not changed significantly after supplementation of Zinc ($p=0.186$). BMI in pre interventional and post interventional groups was 27.97 and 26.99 respectively.

CONCLUSION

Zinc supplementation improves glycemic parameters HbA1C, FBG, PPBG in newly detected Type 2 Diabetics when compared to placebo group. Zinc supplementation with oral hypoglycemic agents may provide better glycemic control. There is no significant effect on fasting lipid profile after Zinc supplementation.

Keywords : Diabetes mellitus, Zinc, hypoglycaemic agents.

INTRODUCTION

Diabetes mellitus (DM) refers to a group of metabolic disorders which is characterized by hyperglycemia. Ebers Papyrus, which was written around 1500 before christ, excavated in 1862 AD from an ancient grave in Thebes, (Egypt) and published by Egyptologist Georg Ebers in 1874, describes, among various other ailments and their remedies, a condition of “too nice emptying of the urine” – perhaps, the reference to DM. For the treatment of this condition, ancient Egyptian physicians were advocating the use of wheat grains, fruit. [1,2] It is one of the diseases described since ancient period in Egypt. At the equivalent time Physicians in Republic of India classified the disease as a separate entity and termed it as Madhumeha or honey urine. [3] During Roman empire DM was considered as rare illness. It was initially seen in upper socioeconomic people due to their life style and food habits. Galen referred the illness as diarrhea urinosa "diarrhea of the urine". Around 230 BC, Apollonius of Memphis for the first time used the term “diabetes,” which in Greek means “to pass through” (dia – through, betes – to go). [3] The first complete clinical description of diabetes appears to have been made by Aulus Cornelius Celsus (30BC–50 AD). [4,5]In 2nd or early 3rd century AD Aretaeus of Cappadocia wrote a book on DM that forms the earliest reference. He described the symptoms of the illness and

its natural course. The first Latin edition was released in Venice after which his work came in light.

Type 1 and Type 2 diabetes were identified as distinct conditions first time by the Indian physicians Sushruta and Charaka in 400-500 AD . Rhey represented Type 1DM associated with youth and Type 2 DM with being overweight. In 1670, Thomas Willis in Oxford noticed the sweet taste of urine of patients with diabetes. Thomas Cawley, in 1788, was the first to suggest the link between the pancreas and diabetes after he observed that people with pancreatic injury developed diabetes.[6] In end of 1700 AD the term "mellitus" or "from honey" was added to Diabetes to differentiate from Diabetes Insipidus by the Briton John Rolle.

It was Banting and Best who created milestone in the history of DM by isolating and purifying Insulin which is effective in managing the cases of DM. They won the noble prize for their most useful discovery. Then the long acting insulin was developed in 1940. Over the years, insulin purification methods improved and new insulin formulations were developed.

Protamine–Zinc insulin, a long-acting insulin, was introduced in the 1930s; Neutral Protamine Hagedorn insulin(NPH) was introduced in the 1940s; and Lente series of insulin in the 1950s.[7] The groundwork for

the production of large quantities of human insulin was laid by Frederick Sanger, who published the structural formula of bovine insulin in 1955.[8] Dorothy Hodgkin (1910–1994) described the three-dimensional structure of porcine insulin in 1969 using X-ray crystallography.[9] The gene coding for human insulin was cloned in 1978 by Genentech. It is located on the short arm of chromosome 11. Once incorporated into the bacterial plasmid of *E. coli*, human insulin gene gets active, resulting in the production of alpha and beta chains of insulin, which were then combined to construct a complete insulin molecule.[10] In 1978, Genentech, Inc. and City of Hope National Medical Center, a private research institution in Duarte, California, announced the successful laboratory production of human insulin using recombinant DNA technology. This was achieved by a team of scientists led by Robert Crea, Keichi Itakura, David Goeddel, Dennis Kleid and Arthur Riggs. Insulin thus became the first genetically manufactured drug to be approved by the FDA. In July 1996, the FDA approved the first recombinant DNA human insulin analog, the insulin lispro. In January 2006, FDA approved inhaled form of insulin marketed under the name of Exubera. This was the first non injectable form of insulin available to patients with diabetes.

Ninety percent of those with diabetes have type-2 diabetes, characterized by insulin resistance, hyper insulinemia, β-cell dysfunction and subsequent β–cell failure. Insulin, is stored as a hexamer containing two Zinc ions in β-cells of the pancreas and released into the portal venous system at the time of β-cells de-granulation. The Zinc ions which are co secreted with insulin suppress inherent amyloidogenic properties of monomeric insulin. Zinc plays a key role in the synthesis and action of insulin, both physiologically and in the pathologic state of diabetes.

AIMS AND OBJECTIVES

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REVIEW OF LITERATURE

DM is a group of metabolic disorders characterized by chronic hyperglycemia. Few forms of DM are characterized in terms of their specific pathogenesis, but the underlying etiology of the most common forms remains unclear. Regardless of the etiology, diabetes progresses through several clinical stages during its natural history. Persons developing the disease can be categorized according to clinical stages and other characteristics even in the absence of knowledge of the etiology. In development of DM there are multiple interaction between genetic and environmental factors. There are so many factors that contribute to development of hyperglycemia such as reduced insulin secretion, decreased glucose utilization, insulin resistance, increased glucose production, increased anti insulin hormone production.

DM is characterized by chronic hyperglycemia with disturbances of carbohydrate, fat, and protein metabolism resulting from defects in secretion of insulin, its action, or both. When fully expressed, diabetes is characterized by fasting hyperglycemia, but the disease can also be recognized during less overt stages, usually by the presence of glucose intolerance. The effects of DM include long-term damage, dysfunction, and failure of multiple organs, especially the eyes, kidneys, heart, and

blood vessels. Diabetes may present with characteristic symptoms such as polydipsia, polyuria, polyphagia, blurring of vision and weight loss, in its most severe forms, with ketoacidosis or non ketotic hyperosmolarity, which, in the absence of effective treatment, leads to stupor, coma, and death. Often symptoms are not severe or may even be absent. Hyperglycemia sufficient to cause pathologic functional changes may quite often be present for a long time before the diagnosis is made. Consequently, diabetes often is discovered because of abnormal results from a routine blood or urine glucose test or because of the presence of a complication. In some instances diabetes may be apparent only intermittently, as, for example, with glucose intolerance in pregnancy or gestational diabetes, which may remit after parturition. In some individuals the likelihood of developing diabetes may be recognized even before any abnormalities of glucose tolerance are apparent. During the evolution of type 1 diabetes, for example, immunologic disturbances such as islet cell or other antibodies are present, and these may precede clinically apparent disease by months or even years . In some families it is possible to recognize certain gene mutations that are strongly associated with certain forms of diabetes, such as variations in the glucokinase gene or hepatic nuclear factor genes that cause young or early adult-onset diabetes. These genetic abnormalities are detectable at

any time. Now DM classification is based on pathogenic process that leads to hyperglycemia. DM is classified into Type 1 and Type 2. Whatever the type of diabetes, a period of abnormal glucose metabolism occurs before full blown disease is diagnosed. Near total deficiency or complete deficiency of insulin leads to Type 1 DM. Type 2 DM can result from variety of causes such as a.) insulin resistance, b.) impaired insulin secretion, and c.) increased glucose production. In Type 2 DM unique genetic, metabolic defects in insulin action or its secretion leads to development of hyperglycemia. Targeting this we have specific pharmacologic agents now. Type 2 DM is preceded by impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). Type-1 DM is an autoimmune disorder and Type-2 DM is a metabolic cum vascular disease.

FIG.3.1 : CLASSIFICATION OF DM

1.Type 1 diabetes[a] (β-cell destruction, usually leading to absolute insulin deficiency)
- Immune mediated
- Idiopathic

2.Type 2 diabetes[a] (can range from predominantly insulin resistance with relative insulin deficiency to a predominantly insulin secretory defect with insulin resistance)

3.Other specific types
- Genetic defects of β-cell function
  - Chromosome 20q, HNF-4α (MODY1)
  - Chromosome 7p, glucokinase (MODY2)
  - Chromosome 12q, HNF-1β (MODY3)
  - Chromosome 13q, insulin promoter factor (MODY4)
  - Chromosome 17q, HNF-1β (MODY5)
  - Chromosome 2q, neurogenic differentiation 1/b-cell e-box transactivator 2 (MODY6)
  - Mitochondrial DNA
  - Others
- Genetic defects in insulin action
  - Type 1 insulin resistance
  - Leprechaunism
  - Rabson-Mendenhall syndrome
  - Lipoatrophic diabetes
  - Others
- Diseases of the exocrine pancreas
  - Pancreatitis
  - Trauma/pancreatectomy
  - Neoplasia
  - Cystic fibrosis
  - Hemochromatosis
  - Fibrocalculous pancreatopathy
  - Others
- Endocrinopathies
  - Acromegaly
  - Cushing's syndrome
  - Glucagonoma
  - Pheochromocytoma
  - Hyperthyroidism
  - Somatostatinoma
  - Aldosteronoma
  - Others
- Drug- or chemical-induced
  - Vacor (pyriminil)
  - Pentamidine
  - Nicotinic acid
  - Glucocorticoids
  - Thyroid hormone
  - Diazoxide
  - β-Adrenergic agonists
  - Thiazides
  - Phenytoin
  - Interferon alpha
  - Others
- Infections
  - Congenital rubella
  - Cytomegalovirus
  - Others
- Uncommon forms of immune-mediated diabetes
  - "Stiff-man" syndrome
  - Anti-insulin receptor antibodies
  - Others
- Other genetic syndromes sometimes associated with diabetes
  - Down's syndrome
  - Klinefelter's syndrome
  - Turner's syndrome
  - Wolfram's syndrome
  - Friedreich's ataxia
  - Huntington's chorea
  - Laurence-Moon-Biedel syndrome
  - Myotonic dystrophy
  - Porphyria
  - Prader-Willi syndrome
  - Others

4. Gestational diabetes mellitus (GDM)

[a]Patients with any form of diabetes can require insulin treatment at some stage of their disease. Such use of insulin does not in itself classify the patient.

Adapted with permission from Report of the Expert Committee.[13]

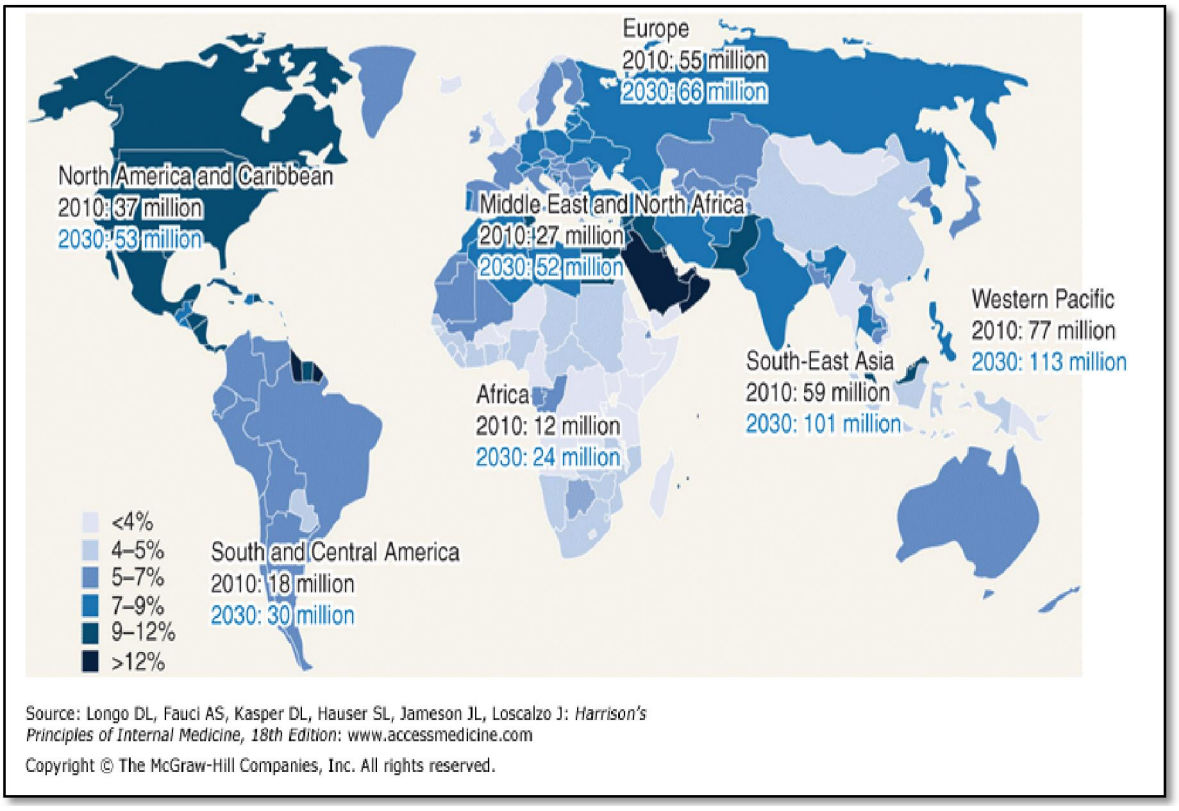
EPIDEMIOLOGY

Globally, as of 2010, an estimated 285 million people had diabetes, with type 2 making up about 90% of the cases.[11] In 2013, according to International Diabetes Federation, an estimated 381 million people had diabetes. Its prevalence is increasing rapidly, and by 2030, this number is estimated to almost double.[13] DM occurs throughout the world, but is more common (especially type 2) in the more developed countries. The greatest increase in prevalence is, however, expected to occur in Asia and Africa, where most patients will probably be found by 2030. The increase in incidence in developing countries follows the trend of urbanization and lifestyle changes, perhaps most importantly a "Western-style" diet. This has suggested an environmental (i.e., dietary) effect, but there is little understanding of the mechanism(s) at present, though there is much speculation, some of it most compellingly presented.[13] India has more diabetics than any other country in the world, according to the International Diabetes Foundation[15] although more recent data suggest that China has even more.[14] The disease affects more than 62 million Indians, which is more than 7.1% of India's Adult Population.[16] An estimate shows that nearly 1 million Indians die due to Diabetes every year.[15] The average age of onset is 42.5 years.[15] The high incidence is attributed to a combination of genetic susceptibility plus adoption of a high-calorie diet, low-activity lifestyle by India's growing middle class.[17] Additionally, a study by the American Diabetes Association

reports that India will see the greatest increase in people diagnosed with diabetes by 2030.[18]

In India, prevalence of DM is about 9.1% in 2013 and expected to rise to 9.7% in 2035. In 2013 number of persons with DM is 65,076,400 and this is expected to rise 109,028,100 in a tough competition for the DIABETIC CAPITAL OF WORLD with China. Number of undiagnosed DM cases in India is estimated to be about 31,920,000 in 2013. In India in 2013 number of deaths attributed to DM is estimated to be around 1,065,053. In South India ,Type-2 DM has a prevalence rate >10% .

FIGURE 3.2: PREVALANCE OF DIABETES



DIAGNOSIS of Type 2 Diabetes is According to American Diabetic Association guidelines as listed below

TABLE 3.1: CRITERIA FOR DIAGNOSIS OF DM :

1) Symptoms of diabetes plus random blood glucose concentration $\geq$ 11.1 mmol/L (200 mg/dL)[a] or

2) Fasting plasma glucose $\geq$ 7.0 mmol/L (126 mg/dL)[b] or

3) A1C > 6.5%c or

4) Two-hour plasma glucose $\geq$ 11.1 mmol/L (200mg/dL) during an oral glucose tolerance test[d]

[a]Random is defined as without regard to time since the last meal. [b]Fasting is defined as no caloric intake for at least 8 h. [c]The test should be performed in laboratory certified according to A1C standards of the Diabetes Control and Complications Trial. [d]The test should be performed using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water, not recommended for routine clinical use. ***Note:*** In the absence of unequivocal hyperglycemia and acute metabolic decompensation, these criteria should be confirmed by repeat testing on a different day. ***Source:*** American Diabetes Association, 2011.

Abnormal glucose homeostasis is

A. FPG -100 -125mg/dl -IFG-Impaired Fasting Glucose

B. Plasma glucose levels after 2 hours following an oral glucose challenge--140 and 199 mg/dl, termed as impaired glucose tolerance (IGT); or

C. HBA1C of 5.7–6.4%.

WHO criteria for the diagnosis of diabetes [27]

1) Symptoms of diabetes plus casual venous plasma glucose-11.1 m mol/l. Casual is defined as any time of day without regard to time since last meal. The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss.

2) Fasting plasma glucose -7.0 m mol/l or whole blood-6.1 m mol/l. Fasting is defined as no calorie intake for at least 8 hours

3) 2 hour plasma glucose -11.1 m mol/l during oral glucose tolerance test using 75 g glucose load.

In the absence of symptoms, these criteria should be confirmed by repeat testing on a different day. If the fasting or random values are not diagnostic, the 2 hour value post-glucose load should be used.

Note:

Fasting plasma glucose -6.1 m mol/l—normal

Fasting plasma glucose -6.1 to 7.0 m mol/l—impaired fasting blood glucose

Fasting plasma glucose -7.0 m mol/l—provisional diagnosis of diabetes; the diagnosis must be confirmed.

The current diagnostic criteria DM relies mainly on A1C or the FPG as they are reliable and convenient parameters . This is also used in asymptomatic individuals.

SCREENING

Every 3 years, Screening of individuals >45 years and the people whose body mass index (BMI) >25 kg/m^2 at an earlier age and having any of additional risk factor for diabetes listed below is essential because,

1. Asymptomatic condition and lack of awareness
2. Early start of the disease before diagnosis
3. At the time of diagnosis patient may have complications related to disease
4. Early treatment prevents complications and delays its progression .

TABLE - 3.2: RISK FACTORS-FOR DEVELOPMENT OF TYPE 2 DM

Family history of diabetes (i.e., parent or sibling with type 2 diabetes)
Obesity (BMI ≥25 kg/m^2)
Physical inactivity
Race/ethnicity (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
Previously identified with IFG, IGT, or an A1C of 5.7–6.4%
History of GDM or delivery of baby >4 kg (9 lb)
Hypertension (blood pressure ≥140/90 mmHg)
HDL cholesterol level <35 mg/dL (0.90 mmol/L) and/or a triglyceride level >250 mg/dL (2.82 mmol/L)
Polycystic ovary syndrome or acanthosis nigricans
History of cardiovascular disease

Abbreviations: BMI, body mass index; GDM, gestational diabetes mellitus; HDL, high-density lipoprotein; IFG, impaired fasting glucose; IGT, impaired glucose tolerance.
Source: Adapted from American Diabetes Association, 2011.

ZINC DEFICIENCY :

Zinc deficiency is more common in developing countries[19], where diabetes is also showing an exponential increase in prevalence. The prevalence of CAD, diabetes and glucose intolerance was significantly higher among subjects consuming lower intakes of dietary Zinc. There was a higher prevalence of hypertension, hypertriglyceridemia and low high-density lipoprotein cholesterol levels which showed significant upward trend with lower Zinc intakes.

Animal studies have shown that Zinc supplementation improves fasting insulin level and fasting glucose in mice.[19] Human studies have also shown the beneficial effects of Zinc supplementation in both type-1[20,21] and type-2 diabetes.[22,23] However, results of isolated randomized controlled trials are frequently contradicted by subsequent studies.[24] Especially, in type-1 diabetes studies have reported a negative effect of Zinc supplementation on glucose homeostasis.[25] Even under the most rigorous study design conditions, even a well-planned single study, rarely provides definitive results and changing clinical practices relying on a single high-profile clinical trial can be harmful to patients health . Well-designed randomized controlled trials are excellent when looking at effectiveness, though many fall short in reporting of safety and adverse events associated with an intervention. Systematic reviews often have increased power and decreased bias as compared with the individual

studies they include, and the careful pooling of treatment effects can provide the most accurate overall assessment of an intervention. Presently there are no systematic reviews exploring the therapeutic efficacy of Zinc supplementation in humans with diabetes. This study aims to systematically evaluate the literature and the effects of Zinc supplementation in humans.

ZINC – AN ESSENTIAL ELEMENT

Zinc is an essential trace element that is important in many biological processes and cellular homeostasis. Disturbed Zinc signaling process is associated with variety of chronic disease states including cancer, cardio vascular disease and diabetes. For maintaining cellular homeostasis and insulin synthesis Zinc is essential. Zinc, an essential mineral that is naturally present in some foods, added to others, and also available as a dietary supplement. Zinc is involved in various cellular metabolisms.

It is also required for the action of many enzymes and it plays a role in immune function[28],protein synthesis, wound healing, cell division and DNA synthesis. It also supports normal growth and development during pregnancy, childhood, it is also required for proper sense of smell and taste.

So a steady daily intake of Zinc is required to because the body has no specialized Zinc storage system.

Zinc is an important component of most of the enzymes like Carbonic anhydrase, peptidase, Alcohol dehydrogenase, Alkaline phosphatase, Polymerase, Superoxide dismutase, Angiotensin converting enzyme, Collagenase, Amino levulinic acid, Protein Kinase C, Phospholipase, RNAse etc.

Recommended dietary allowances (RDA)

Average daily level of intake sufficient to meet the nutrient requirements of nearly all healthy individuals. The current RDAs for Zinc are listed in table 3.

TABLE 3.3: RECOMMENDED DIETARY ALLOWANCES(RDAS) FOR ZINC [30]

Age	Male	Female	Pregnancy	Lactation
0-6 months	2mg	2mg		
<3 years	3mg	3mg		
4-8 years	5mg	5mg		
9-13 years	8mg	8mg		
14-18 years	11mg	9mg	12mg	13mg
19+	11mg	8mg	11mg	12mg

Tolerable upper intake intake level (UL) : [30]

Prolonged intake above the upper limit increases the risk of adverse health effects. [30]Importantly these upper limits are not applicable for those who are receiving Zinc for medical treatment, but such individuals should be under the care of a physician who monitors them for adverse effects.

TABLE 3.4: TOLERABLE UPPER INTAKE LEVELS FOR ZINC[30]

Age	Male	Female	Pregnant	Lactating
0-6 months	4mg	4mg		
7-12months	5mg	5mg		
1-3 years	7mg	7mg		
4-8 years	12mg	12mg		
9-13 years	23mg	23mg		
14-18 years	34mg	34mg	34mg	34mg
19+ years	40mg	40mg	40mg	40mg

Major Causes of Zinc Deficiency : [29]

A. Inadequate intake :

1) Low-Zinc-containing diets:

Vegetarians (foods poor in animal origin)

2) Loss of Zinc during food processing : (desalting during production of artificial milk)

3) Prolonged enteral nutrition

B. Malabsorption

1) Congenital : Acrodermatitis enteropathica

2) Acquired:

   a) Ingestion of absorption inhibitors - phytic acid, fibers

   b) Malabsorption syndromes – Liver dysfunction, Pancreatic dysfunction, Inflammatory Bowel disease etc

   c) Chelating agents: EDTA, Pencillamine

C. Increased elimination :

   a) Loss into digestive fluids – chronic diarrhea, intestinal fistula

   b) Enhanced urinary elimination – Diabetes, Kidney disease, Hemolytic anemias, Diuretics

   c) Others : Surgery, Infections, Trauma, Burns

D. Enhanced demand :

   a) Pregnancy, Premature babies

   b) Enhanced anabolism

TABLE 3.5: POSSIBLE CONDITIONS SUGGESTED BY SERUM ZINC LEVELS AND ITS IMPLICATIONS[29]

SERUM ZINC LEVELS (MICROGM/DL)	CONDITIONS	IMPLICATIONS
84-159	Normal Range	
60-83	Mild deficiency	Identification of cause Zinc replacement
<59	Moderate deficiency	Identification of cause Zinc replacement
<30	Severe deficiency	Identification of cause Zinc replacement
>160	Intoxication	First aid and follow up

Uses of Zinc : [31]

Diarrhea in malnourished children	10-40 mg elemental Zinc daily for 14 days in Acute Watery Diarrhoea as per the requirement of IMNCI guidelines of government of India.
Attention defecit hyperactivity	55 mg Zinc sulphate (15 mg elemental Zinc) to 150 mg (40 mg elemental Zinc) daily.

Osteoporosis	15mg Zinc combined with 5 mg manganese, 1000 mg calcium, and 2.5 mg copper has been used.
Treatment of pneumonia	10-70 mg/day
Hypogeusia (a sense of abnormal taste)	25-100 mg/day
Anorexia nervosa	100 mg of Zinc gluconate daily
Gastric ulcers	Zinc sulphate 200 mg three times daily.
Muscle cramps in liver diseases	Zinc sulphate 220 mg twice daily.
Sickle cell disease	Zinc sulphate 220 mg three times daily.
To increase growth and weight gain in children with sickle cell disease who have not reached puberty	Zinc 10 mg (elemental) per day.
Acne vulgaris	30-135 mg elemental Zinc daily.
Age related macular degeneration:	Elemental Zinc 80 mg plus vitamin C 500 mg, vitamin E and vitamin A 15 mg daily.

Common cold:

One Zinc gluconate or acetate lozenge, providing 9-24 mg elemental Zinc, can be taken by mouth every two hours while awake when cold symptoms are present.

Different salt forms:

Zinc sulphate contains 23% elemental Zinc ; 220 mg of Zinc sulphate contains 50 mg elemental Zinc. Regards Zinc gluconate it contains 14.3% elemental Zinc; 10 mg Zinc gluconate contains 1.43 mg Zinc.

Toxicity :

Zinc toxicity can occur in two types:

1) Acute form

2) Chronic form

1) Acute form:

Acute adverse effects of high Zinc intake include the following nausea, vomiting, abdominal cramps, diarrhea, and headaches and loss of appetite (2). One study showed that severe nausea and vomiting within 30 minutes of ingesting 4 gram of Zinc gluconate (570 mg elemental Zinc).[32]

2) Chronic form:

Intake of 150-450 mg of Zinc per day have been associated with chronic effects like low copper status, affecting iron metabolism, reduced immune function, and reduced levels of high density lipoproteins. [33]

Afkhami-Ardekani et al., reported that patients receiving Zinc sulphate 660 mg /day for 12 weeks had mild abdominal pain (19). Patients who received Zinc sulphate (22 mg /day) and Zinc acetate (50 mg /day) for a period of 34 months showed that no significant adverse effects on renal and liver function tests.[33]

Diabetes and Zinc

DM type 2 is charecterised by hyperinsulinemia, dysfunction of beta cells and cellular failure.[34] Insulin is stored as a hexamer containing 2 Zinc ions in cells of pancreas and released into the portal circulation at the time of beta cell degranulation.[35] The Zinc (II) ions which are co-secreted with insulin suppress the inherent amyloidogenic properties of monomeric insulin.[36] Zalewski et al showed that high concentration of glucose and other secretogogues decrease the islet cell labile Zinc and video fluroscence analysis showed Zinc concentration in the islet cells was related to the synthesis, storage and secretion of insulin.[37] In vitro data suggests that insulin binds to isolated liver membranes to a greater extent and that there is less degradation when co-aDMinistered with

Zinc.[38] Zinc is important in insulin action and carbohydrate metabolism.[39] Oxidative stress is important in development of diabetes and its vascular complication. Zinc is also a part of anti oxidant enzymes like superoxide dismutase and its deficiency leads to oxidative stress. Studies have shown that diabetes is charecterised by hypoZincemia [40] and hyperZincuria.[41] In addition Zinc deficiency is more common in men of developing countries [42] where diabetes is more common. Animal studies have shown that Zinc supplementation improves fasting insulin level and decreases fasting glucose in mice.[43] Human studies have shown that the beneficial effects of Zinc supplementation in both type1[44,45] and type 2DM .[46,47]

The cellular homeostasis is particularly achieved through the actions of Zinc transporters and metalothioneins. In diabetes the role of Zinc is emerging now. Zinc is very important in the synthesis , storage and secretion of insulin in both physiological and patho physiological states. It also plays a dynamic role as a cellular second messenger in the control of insulin signaling and glucose metabolism. This suggests that Zinc plays an unidentified role as a second messenger that augments insulin activity and synthesis. In the recent era DM is characterized by dysfunctional signaling. The fact that insulin crystals contain Zinc [49] and this cation facilitated a supportive role in diabetes. Zinc, also has an essential role in maintaining normal physiological function.[50,51] Disturbances in Zinc homeostasis have been observed in diabetes [49,50-52]

and many other chronic conditions like cancer [53,54], auto immune disease[55,56], cardio vascular disease [57] and Alzhiemer's disease.[58,59]

Zinc has a variety of biological implications like catalytic, regulatory and structural.[60] Growth factors, cytokines, receptors, enzymes and transcription factors belonging to cellular pathways contains Zinc as a major cation.[61] Also it has a very essential role in numerous cellular processes as a cofactor for more than 3000 human proteins including nuclear factors, hormones and enzymes.[62] Mechanism that modulate Zinc absorption, distribution, excretion and cellular uptake are very essential for normal cellular function. These processes are maintained through various class of transport proteins that modulate the uptake, efflux and compartmentalisation of Zinc.[63]

Recent studies shown that 4 metellothionines (MTs) 14 Zinc importers (SLC 39/ZiPs) and 10 Zinc exporters (SLC 30/ZnTs) have been described in mammals.[64] These metallothionines are the major Zinc binding proteins that plays an important role in Zinc uptake , storage, release and distribution.[65,66] The Zinc transporters are very important for Zinc metabolism where the ZiP transporter contribute to a net increase in cytosolic Zinc , while the ZnTs cause a net decrease in cytosolic Zinc . In 1980 ,Coulstan and Dandora [67] discovered that Zinc exerted a potent stimulating effect upon lipogenesis in rat adipocytes independent of and additive to that of insulin. These findings suggest that the effects of this

cation may have physiological relevance in controlling insulin signaling pathways since Zinc is essential for the crystallization of insulin in hexameric complexes and is cosecreted with insulin on exposure to high glucose . Similarly May and Controggi[68], utilizing supra physiological concentrations (250-1000micromol) of Zinc chloride, revealed a role for this cation in stimulating glucose transport and oxidation incorporation of glucose carbon into glyceride glycerol and glyceride –fatty acid and inhibition of ritodrine stimulated lipolysis in rat adipocytes.

Some studies have suggested that Zinc as an inhibitor of protein tyrosine phosphatases (PTP) [69]. In fact inhibition of PTB 1 a negative regulator of insulin signaling activity ameliorates high fat diet induced insulin resistance.[70] The mechanisms of insulin mimetic activity of Zinc on glucose [71-75] and lipid metabolism have been demonstrated in various studies. Cumulative evidence has revealed that Zinc as a direct signaling molecule implicated in extra cellular signal recognition, second messenger metabolism, protein kinase activity, protein phosphorylation.[76] Zinc plays a dynamic role as a second messenger in the control of insulin signaling and glucose homeostasis.[77]

Insulin is critically important anabolic hormone implicated in maintaining normal blood glucose levels. Zinc mediates these effects in part through the inhibition of protein tyrosine phosphatases which

increases the net phosphorylation of insulin receptor and activates its signaling cascade.

Zinc is an essential micro nutrient that is required for various cellular function. Zinc is considered important because it plays a major role in the stabilisation and synthesis of insulin hexamers and the pancreatic hormones. It also has a potent anti-oxidant and anti-inflammatory agent. Zinc may improve glycemia and restored normal Zinc status in diabetic individuals may counteract the deleterious effects of oxidative stess,helping to prevent complications associated with diabetes.

Following are the important effects of Zinc on cellular homeostasis:

1) Stimulation of glucose uptake,
2) Lipogenesis in adipocytes,
3) Tyrosine phosphorylation of the insulin / IGF-1 receptor and insulin receptor substrate -1,
4) Activation of epidermal growth factor receptor,
5) Inhibition of PTP,
6) Activation of mitogen activated kinases (MAPKs),C- jun N-terminal kinases,
7) Increase in glycogen synthesis.

Molecular and cellular studies in animal models have shown that Zinc plays an important role in the synthesis, storage and action of insulin under normal physiologic conditions.

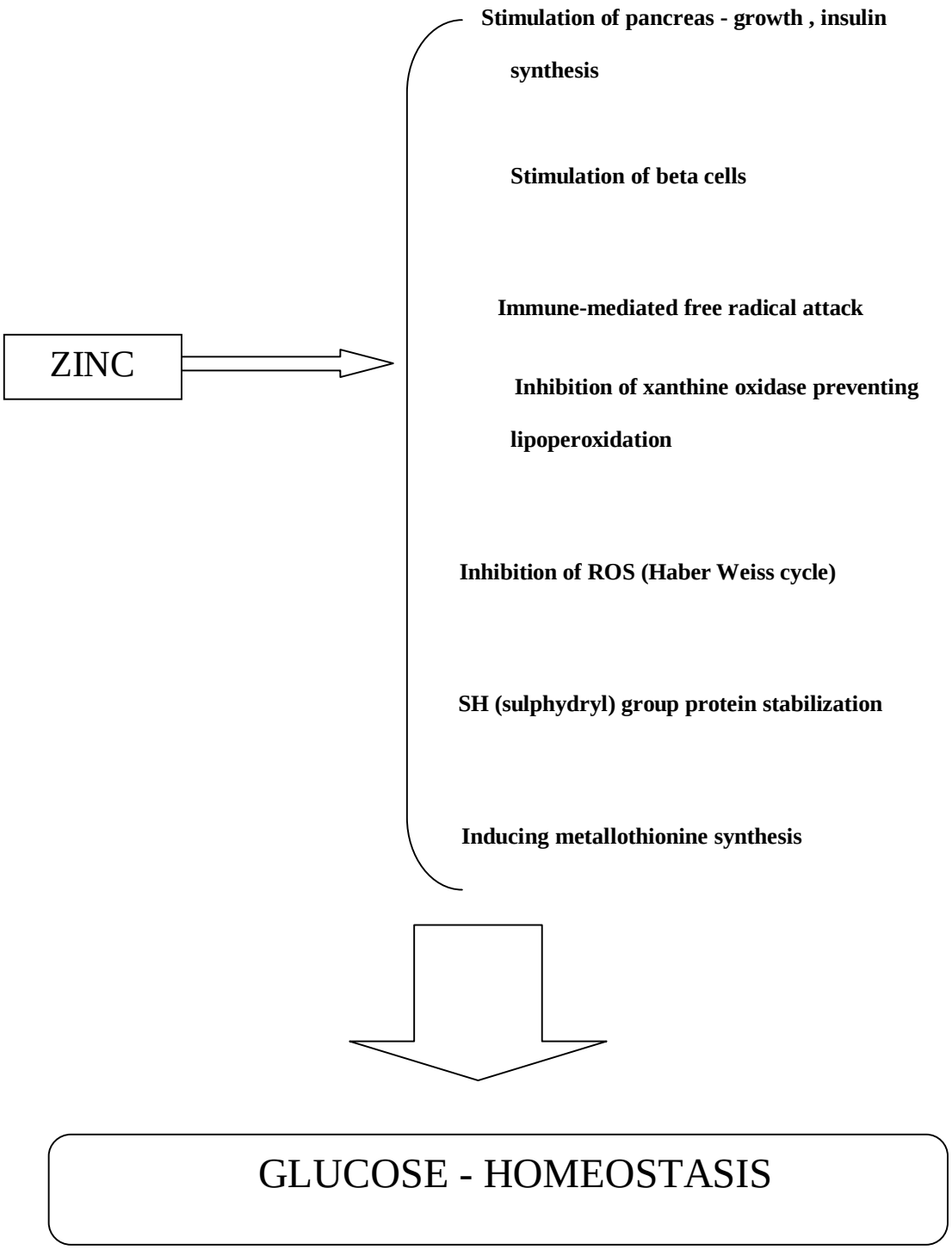
Coustan et al have demonstrated that Zinc stimulated lipogenesis in rat adipocytes similarly to insulin.[78] In some another study insulin secretion was potentiated following Zinc supplementation.[79] Dietary Zinc supplementation in young mice for a period of 6 weeks showed improvement in fasting hyperglycemia and hyper insulinemia. In humans there is no definitive data about the role of Zinc in insulin resistance. All patients with diabetes have low serum Zinc levels but this is likely to be due to hyperZincuria (losing Zinc in the urine secondary to nephropathy in diabetes) and impaired Zinc absorption.[80] There is less degradation of insulin when co administered with Zinc. Zinc is important in insulin function. Studies have shown that diabetes is accompanied by hypoZincemia and hyperZincuria.

The trace element Zinc is known to play an important role in pancreatic islets as a specific structural component of the insulin molecule and also in insulin secretion.[81] Zinc has been shown to possess both antioxidant and anti-apoptotic properties. The availability of Zinc is controlled by two major families of transporters, the Zrt- and Irt-like protein (ZIP) family (responsible for Zinc influx into cells) and the ZnT family(responsible for intracellular transport of Zinc into organelles or

Zinc efflux from cells). Whether alteration of Zinc transporters contributes to stress and cell death during islet cell transplantation is presently unknown. However, autoimmunity targeting Zinc transporter proteins, in particular the ZnT family member ZnT8, has action and carbohydrate metabolism. Polymorphisms for the same Zinc transporter also confer risk in type 2diabetes (T2D). The highest Zinc content in the body has been detected in the islets. Most of the intracellular Zinc is stored with insulin in the insulin secretory vesicles in pancreatic β-cells as a Zinc insulin complex. The concentration of Zinc in these vesicles is very high, approximately 20mM.[82] However, Zinc transporters are also found in pancreatic α-cells and are supposed to regulate glucagon secretion.[83] During insulin secretion, Zinc is released together with insulin into the extracellular islet space, and is taken up by neighboring cells.[83] Within β-cell insulin granules, each hexameric insulin crystal contains two Zinc ions. [84] Zinc deficient rats have lower insulin secretion andglucose uptake compared to normal rats.[85] Faure and colleagues demonstrated that Zinc depletion decreased insulin activity in rats.[85] Nutritional Zinc supplementation improved fasting insulinemia and glycemia in rodents. The mechanism of action of Zinc, whether it acts directly on insulin receptors and glucose transporters, or indirectly via intracellular pathways of insulin, is unknown.[86] During insulin exocytosis, insulin granules fuse with the β-cell plasma membrane, and release their content into the pancreatic micro-circulation.[87] The important role of Zinc in pancreatic β-cell function requires that these

cells are equipped with specialised mechanisms to take up Zinc and incorporate it into their secretory granules.[88]

FIG 3.3: ZINC AND ITS EFFECTS IN HYPERGLYCEMIA



Islet oxidative stress and Zinc as an antioxidant

Oxidative stress

Islets have considerably higher proportion of pancreatic blood supply compared with pancreatic acinar tissue, and this unit terribly sensitive to hypoxia and hypoxia-induced oxidative stress. [89, 90] The chronic hyperglycemia that happens in diabetes also causes oxidative stress and promotes the formation of reactive oxygen species (ROS), [91] leading to mitochondrial pathology,[92] endoplasmic reticulum stress, [93-95] and finally leads to β-cell dysfunction.[96] Oxidative stress additionally plays a vital role in decreasing islet cell viability throughout isolation and transplantation. [97] During islet transplantation procedures, islets undergo hypoxia and decreased oxygen consumption .This initiates biochemical reactions leading to the production of ROS, and subsequent damage and injury to the islets [98, 99]. Increased oxidative stress in islets during this period is partly due to decreased expression of antioxidant enzymes, such as glutathione peroxidise, catalase, and xanthineoxidase. [100]

Zinc as an antioxidant :

The antioxidant properties of Zinc in organs like skin and lung have been thoroughly investigated. However, the role of Zinc as antioxidant in the pancreas has not been extensively studied. Disturbances in Zinc homeostasis, and in particular Zinc depletion, in the pancreas

have been associated with oxidative stress. [101] In some studies, Zinc supplementation has been found to reduce the progression and complications of diabetes by reducing oxidative stress and apoptosis. [102-104] Zinc plays an important role in the maintenance of the structural integrity of copper Zinc superoxide dismutase (Cu-Zn SOD).[105] Zinc supplementation increases superoxide dismutase activity *in vitro*. Correspondingly, SOD activity in Zinc-deficient rats is decreased. Zinc supplementation of Diabetic patients can prevent decreased synthesis of the Zinc-containing antioxidant enzymes superoxide dismutase and glutathione peroxidase, and thereby reducing the excretion of albumin in micro albuminuric Diabetic patients. [106]Another catalyst important in oxidative stress is xanthine oxidase, which catalyses the hydroxylation of xanthine to form superoxide radicals. Zinc inhibits xanthine oxidase activity *in vitro*, thereby reducing lipid peroxidation. [107] In humans, Roussel and colleagues demonstrated that 30 mg/day of Zinc as supplementation reduced lipid peroxidation within the blood samples. [108] It was proposed that Zinc metallothionein complex inhibits xanthine oxidase by interrupting the binding of iron in the Fenton reaction and subsequent redox reaction. [109] In pancreatic islets, Zinc as a component of Zinc metallothionein complexes provides protection against the inflammatory reaction induced by multiple low doses of streptozotocin. [110] Mechanistically, Zinc-upregulated metallothionein inhibits OH generation by inhibiting the Fenton reaction through the binding of Fe2+. Zinc is concerned in protecting sulfhydryl groups against oxidation and in

inhibiting free radical production in the Haber Weiss cycle by competing with transition metals. [110,111] By preventing proteins from oxidation, Zinc contributes to sulphydryl [SH] stabilization . In summary, Zinc has antioxidant properties mediated through SOD and metallotheionein pathways protecting proteins from reactive oxygen species and free radical attacks.

Zinc plays a fundamental role in the structural integrity of insulin. The availability of Zinc is crucial for normal insulin formation and secretion. Zinc also stabilizes the enzymes that protect against apoptosis. It is thus an important antioxidant. Zinc transporters are also important proteins, which regulate the availability of Zinc.

Zinc and its effect on lipids

Atherosclerosis is a chronic oxidative inflammatory disease characterized by deposition of lipids in the artery wall and infiltration of inflammatory cells. It is initiated, in part, by the interaction of oxidized low-density lipoprotein (ox-LDL) with cells of the vascular wall. Vascular oxidative stress is an important pathologic event in atherosclerosis. When LDLs are oxidized, they are readily taken up into macrophages, promoting foam cell formation and the development of atherosclerotic plaque. Once developed atherosclerotic plaque may remain stable or it may leads to rupture resulting in acute coronary syndromes such as myocardial infarction.

Oxidative stress is often defined as an imbalance of pro-oxidants and antioxidants, which can be quantified in humans as the redox state of plasma reduced glutathione/oxidized glutathione (GSH/GSSG). Plasma GSH redox in humans becomes oxidized due to age, chemotherapy, smoking, and in common diseases such as type 2 diabetes and cardiovascular disease.

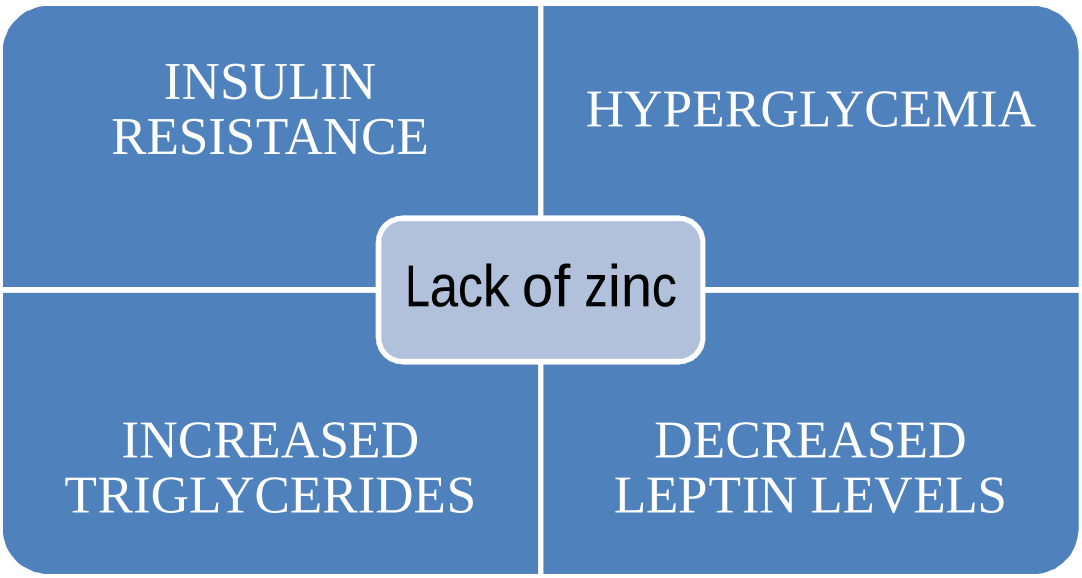
Zinc is an essential trace element that is vital in maintaining normal physiology and cellular functions. It is one of the most abundant metals in the human body, second to iron. The importance of Zinc is apparent from the enormous number of proteins that contain Zinc ions in their structure. Zinc has catalytic and structural functions in thousands of enzymes and regulatory functions in a growing list of proteins. Ten percent of genes encode Zinc-containing proteins. Because of its anti oxidant property it is implicated in the prevention of atherosclerosis.

Knowledge about the requirements and importance in maintaining the integrity of vasculature particularly the vascular endothelium is very little. Zinc is required for normal cellular repair processes and also atherosclerosis is believed to begin with endothelial cell injury, decreased serum Zinc concentration in the vascular tissues may be involved in either initiation of endothelial cell injury, potentiation of oxidative stress and inflammatory response or inadequate protection against apoptosis.

It also acts like anti atherogenic substance by interfering with the signaling pathways involved in apoptosis. It is very likely that certain lipids and Zinc deficiency may potentiate the cytokine-mediated inflammatory response and endothelial cell dysfunction in atherosclerosis. The involvement of Zinc in the pathology of atherosclerosis is not clear.

Zinc and its effect on weight :

FIGURE 3.4: ZINC AND ITS ROLE IN WEIGHT



Zinc acts as an assistant in weight control by a variety of ways.

Firstly

Lack of Zinc affects the insulin receptors on the cells, so the blood glucose levels go up, the beta cells produce more insulin, which means there is more unused insulin in the blood. As insulin promotes fat storage having high levels will also cause weight gain.

Secondly

Too much of copper can increase the conversion of glucose into triglycerides. (Around the world, copper can be a problem because of an increase in the use of copper water pipes for water distribution). This is heavily increasing the intake of copper in many areas.

Zinc is what is known as a copper ‘antagonist’ or ‘competitor’ - in other words it competes with copper both for absorption in the intestine and for binding sites on albumin molecules. This causes lower levels of copper and thus the production of fewer triglycerides. It has been found that an excess of either of these two minerals leads to a deficiency in the other.

Thirdly

Leptin a hormone produced in the fat cells has been found to regulate blood sugar by adjusting the amount of energy available. Lack of Zinc decreases the blood levels of leptin. So it plays a role in appetite control, storage of fat and amount of glucose stores in the liver.

TYPE 2 DIABETES - AN INFLAMMATORY DISEASE

Type 2 Diabetes is nowadays viewed as an auto inflammatory disease. As evidenced by several studies, there are elevated levels of acute phase proteins such as CRP, haptoglobin, Fibrinogen and also cytokines and chemokines in Type 2 Diabetes . It is also postulated that Interleukin-1β and Interleukin -6 ,CRP are predictive of Type 2 Diabetes . And also Interleukin 1 receptor antagonist are said to be increased in obesity and in pre diabetic state in significant levels. These biomarker levels are elevated if there are any associated Type 2 Diabetes with complications either micro vascular or macro vascular. Adipose tissue is a major site of production of inflammatory markers and presence of excess of adipose tissue as in obesity initiates and leads to establishment of inflammation in the body as depicted below.

FIG 3.4 : DEVELOPMENT OF INFLAMMATION IN TYPE 2 DIABETES

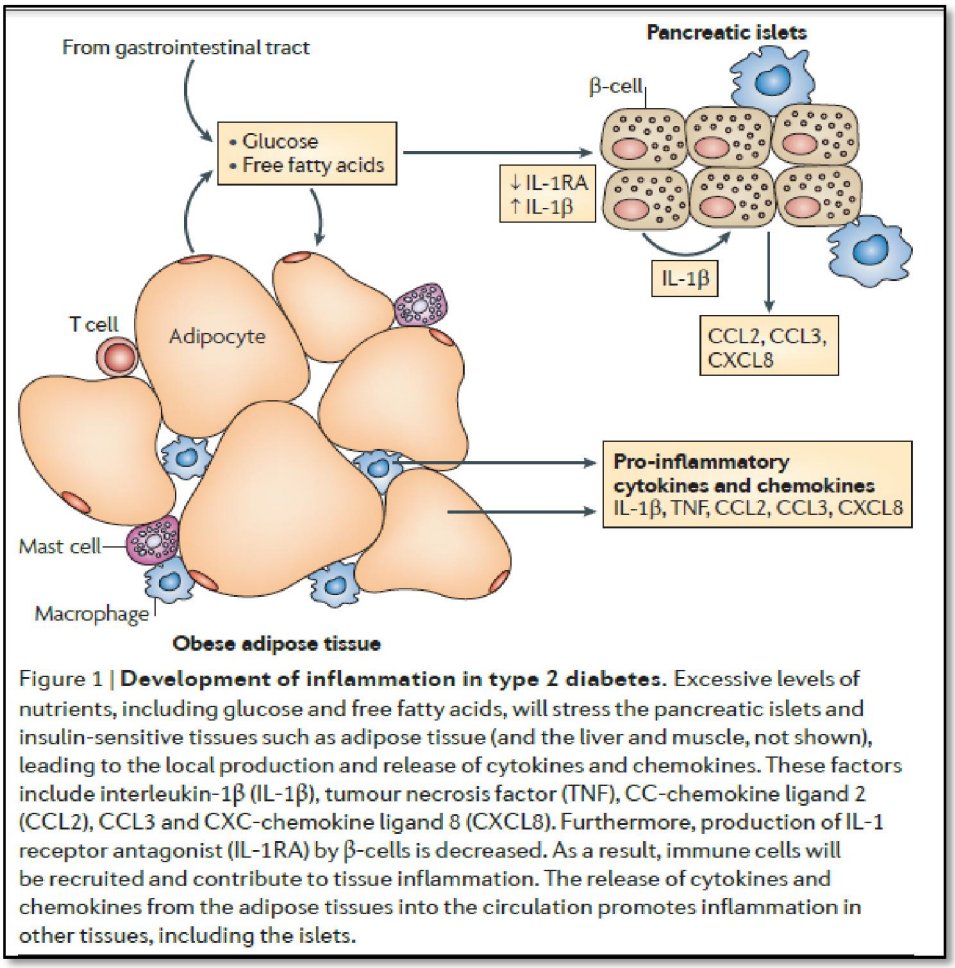


Figure 1 | **Development of inflammation in type 2 diabetes.** Excessive levels of nutrients, including glucose and free fatty acids, will stress the pancreatic islets and insulin-sensitive tissues such as adipose tissue (and the liver and muscle, not shown), leading to the local production and release of cytokines and chemokines. These factors include interleukin-1β (IL-1β), tumour necrosis factor (TNF), CC-chemokine ligand 2 (CCL2), CCL3 and CXC-chemokine ligand 8 (CXCL8). Furthermore, production of IL-1 receptor antagonist (IL-1RA) by β-cells is decreased. As a result, immune cells will be recruited and contribute to tissue inflammation. The release of cytokines and chemokines from the adipose tissues into the circulation promotes inflammation in other tissues, including the islets.

Due to the inflammation, insulitis results and initial steps for Type 2 Diabetes are laid down . In Type 2 Diabetes inflammatory mechanisms said to be present are

1. Hypoxia
2. Adipocyte cell death
3. Metabolic stress--- Cytokine- NF-κB and JNK pathway
4. IL- 6 and insulin resistance .

Zinc has a concentration-dependent effect on peripheral blood mononucleate cells (PBMC). It can inhibit or stimulate the assembly of proinflammatory cytokines such as IL-1 and TNF-α. Zinc supplementation of human PBMC leads to an increased messenger ribo nucleic acid production and release of the cytokines IL-6, IL-1β, and TNF-α. On the other hand, several studies showed that Zinc treatment suppresses the formation of pro-inflammatory cytokines such as TNF-α, IL-1β and IL-8 . Kee-Lung and colleagues showed that the result of Zinc is concentration-dependent. [54] Zinc administration of 100 μM stimulated cytokine production and expression of caspase-3 and pro-apoptotic genes, including Fas (FasL) and c-fos. Zinc concentrations above 100 μM decreased cytokine stimulation and the expression of the anti-apoptotic factors nuclear factor (NF) κB, Bcl-2, and Bcl-XL in PBMC from healthy subjects . [54]Zinc supplementation decreased TNFα-induced NF-κB activity in PBMC. Zinc supplementation in cell lines upregulated anti-apoptotic protein Zinc finger protein A20 *in vitro* . A20 inhibits the activity of pro inflammatory cytokines via TNF receptor-associated factors in cells . A20 is expressed in various cell types in response to a number of stimuli, such as TNFα, IL1-β, Epstein-Barr virus latent membrane protein, and others. A20 inhibits the activation of NF-κB by IL-1β and TNF-α gene expression in endothelial cell. Cooper and colleagues suggested that A20 may play a role in regulating gene expression of IL-1β, IL-8, and TNF-α affected by Zinc .[60]

In 2004 Hiroyuki YANAGISAWA studied Zinc deficiency and clinical practice and concluded that for Zinc deficiency treatment 30mg/day can be given.

In 2011 Priyanka kunasekara et al studied effects of Zinc and multivitamin tablets on adult diabetes to evaluate the effects of Zinc with or without other antioxidants on blood glucose, lipid profile, and serum creatinine in adult diabetics on long-term follow-up and concluded that it has beneficial effects in decreasing HbA1c levels in addition to elevating serum Zinc levels.

In 2012 Jihye kim et al studied the effects of Zinc supplementation on insulin resistance and metabolic risk factors and concluded that Zinc supplementation has beneficial effects on insulin activity.

In 2012 Md.Rafiq Islam et al studied the association of serum Zinc level with Prediabetes and Diabetes and concluded that serum Zinc level is significantly lower in prediadetes when compared to healthy subjects.

In 2011 Mariea D Bosco et al studied about Zinc and Zinc transporter regulation in pancreatic islets and concluded that Zinc plays a fundamental role in the structural integrity of insulin, the availability of Zinc is crucial for normal insulin function, secretion and it also stabilizes the enzymes that protect against apoptosis.

In 2009 Qi Sun et al studied about the intake of Zinc in relation to risk of type 2 diabetes and concluded that higher Zinc intake may be associated with slightly lower risk of type 2 diabetes in women.

In 2013 Priyanga Ranasinghe et al studied about Zinc supplementation in pre-diabetes and concluded that the study will provide a step change in the evidence guiding current and future policies regarding dietary supplementation in prevention of diabetes.

In 2013 Saeed Akhtar et al studied prevalence of Zinc deficiency and its health and economic consequences in South Asian developing countries and concluded that Zinc deficiency in South Asian developing countries is considerably prevalent. Populations from India, Nepal, Sri Lanka, and Pakistan are also affected by Zinc deficiency. Inadequate intake of Zinc has been regarded as one of the most significant causes of Zinc deficiency.

In 2012 Stephen A. Myers et al studied about Zinc transporters, mechanisms of action and therapeutic utility and implications for type 2 DM and concluded that Zinc transporters play a crucial role in insulin and glucose metabolism.

In 2014 Foster et al studied that Zinc transporter gene expression and glycemic control in women with type 2 DM and concluded that there is an association between Type 2 DM and Zinc homeostasis.

In 2011 Ruz et al studied whether Zinc has a potential coadjuvant role in the therapy of type 2 diabetes and concluded that Zinc supplementation may have beneficial effects on glycemic control.

In 2007 Beletate et al studied about the effect of Zinc supplementation in the prevention of type 2 DM and concluded that

there is currently no evidence to suggest the use of Zinc supplementation in the prevention of type 2 DM. Future trials will have to standardise outcomes measures such as incidence of type 2 DM, decrease of the insulin resistance, quality of life, diabetic complications, all-cause mortality and costs.

In 2013 Vashum p et al studied the association between the serum Zinc levels with pancreatic beta cell function and insulin sensitivity in pre-diabetic and normal individuals and concluded that higher serum Zinc concentration is associated with increased insulin sensitivity.

In 2001 Anderson et al studied about the antioxidant effect of Zinc and chromium in diabetic people and concluded that combined supplementation provides better anti oxidant effect and glycemic control in the diabetic population.

In 1986 Niewoehner CB et al studied the effect of Zinc supplementation in diabetic people and concluded that Zinc deficiency causes deranged immune function in diabetes.

In 2006 Al-Maroof RA et al studied to assess serum Zinc level in a sample of diabetic patients (both type 1 and type 2 diabetics) in comparison with those of apparently healthy controls and concluded that Zinc supplementation decreases HbA1c levels significantly in diabetic patients when compared to healthy subjects.

In 2014 Mekwasan K et al studied the association between anti cancer effect of Zinc in diabetic patients and concluded that Zinc has beneficial effect.

In 2008 Xiang J et al studied about Zinc transporter and diabetes and concluded that Zinc transporter has definite association with diabetes and variations in this transporter leads to increased susceptibility to diabetes.

In 2005 de Sena KC et al conducted a study to identify the effect of oral Zinc supplementation in patients with type 1 diabetes (T1DM) on metabolic control and Zinc blood concentrations and concluded that unsatisfactory results in diabetes.

In 2003 Roussel et al studied the relationship between the antioxidant effect and Zinc and concluded that Zinc has strong anti oxidant effect in patients with diabetes.

In 2007 Islam et al studied the interactions between diabetes, metallothionein and Zinc and concluded that Zinc enhances the synthesis of metallothioneins which decreases the oxidative stress in patients with diabetes.

MATERIALS AND METHODS

POPULATION FRAME

Patients attending Medicine OPD in ESI PGIMSR , KK Nagar, Chennai who are newly diagnosed to have Type 2 Diabetes as per ADA guidelines were recruited. During the study all the new adult patients who presented to the OPD with complaints of easy fatigability, polyuria, polyphagia, polydipisia or with risk factors for Diabetes or referred from the ESI dispensary after the initial urine glucose test or from other allied departments were screened for Diabetes by HBA1C and FBG. All the patients were screened and after meeting eligibility criteria they were recruited in the study.

PERIOD OF STUDY

- 12 Months (2013-14)

DESIGN OF STUDY

Placebo controlled, prospective, Randomized, double blinded interventional study. Patients enrolled in the study were clearly instructed not to vary their routine day to day activities and not to take any forms of Zinc supplementation other than what that has been given for the study. The subjects were also asked to fast for a minimum of 8 hours before coming to OPD for investigations.

INCLUSION CRITERIA

1. Newly diagnosed Type 2 diabetic subjects without complications, attending ESIC PGIMSR MEDICAL OPD ,KK Nagar,Chennai-78.
2. Age ≥ 20.
3. Gender – both male and female.

EXCLUSION CRITERIA

1. Type-1 Diabetes,
2. Type-2 diabetics with complications
3. Diabetes in pregnancy
4. Chronic kidney disease
5. Chronic Liver Disease, Chronic Pancreatitis or IBD (Inflammatory Bowel disease)
6. Subjects on Zinc supplementation, Immunomodulators drugs, chelating drugs.

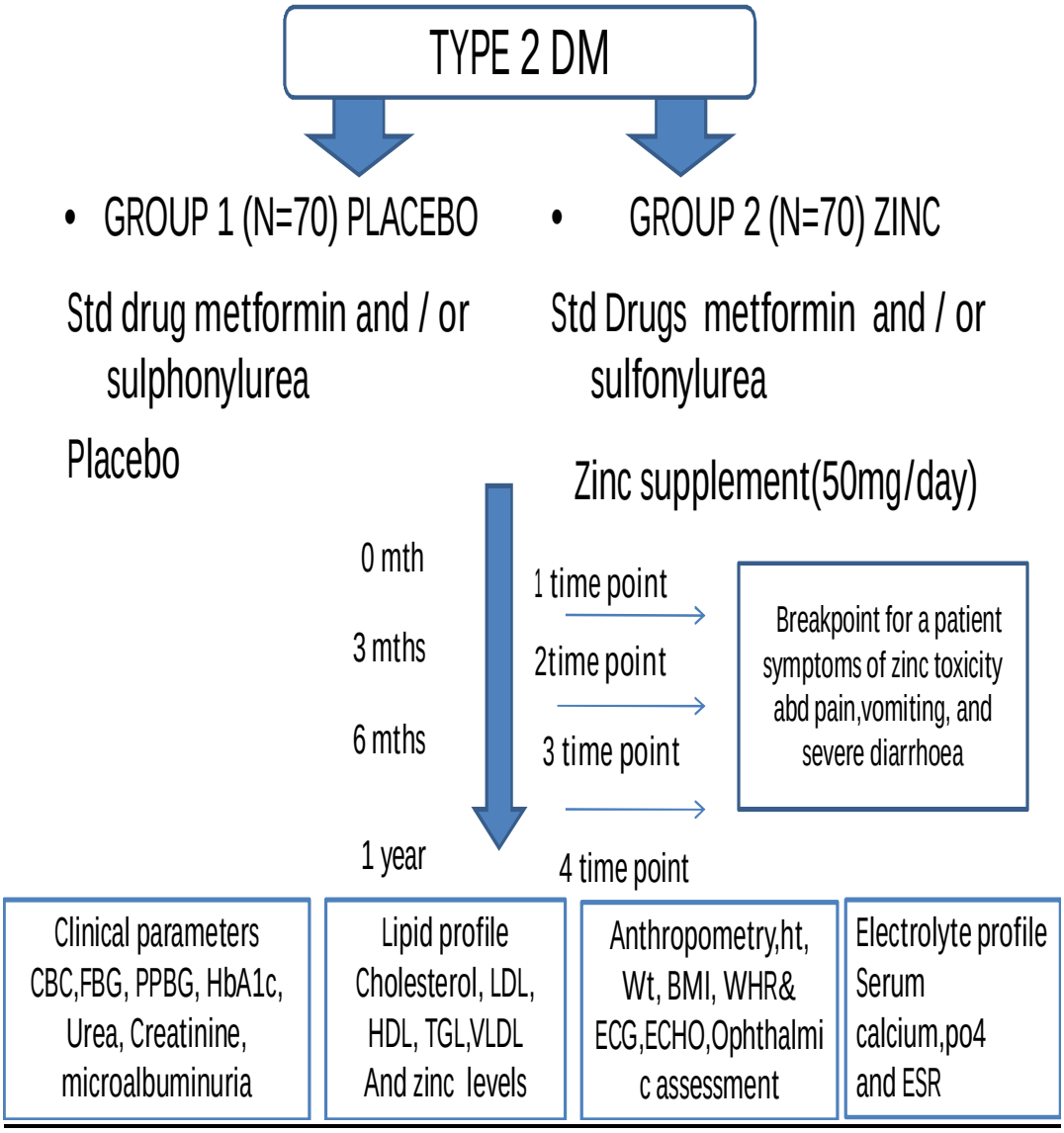
CONSENT

All patients were recruited in the study after getting consent in the consent form in vernacular language. Consent form was approved by Institutional Ethical Committee, ESI PGIMSR, KK Nagar.

METHODS

All the new patients attending the OPD with risk factors for DM or the patients referred from ESI Dispensary after urine glucose was positive or from other departments were initially selected and after getting consent regarding investigations and further inclusion in the study, patients were subjected to FBG and HBA1C. After exclusion of patients with IFG or IGT or with normal glucose levels, remaining patients of about 140 patients were subjected to Ultra sonogram abdomen to rule out chronic kidney disease, chronic liver disease, fundus examination to rule out Diabetic Retinopathy and ECG, Blood Urea Sr.Creatinine, Urine routine examination along with early morning urine microalbuminuria were done. After completing investigations 140 patients were divided randomly into two groups according to computer generated random number. So each group consisted 70 patients . Patient groups are assigned as 1 and 2.

METHODOLOGY



Investigation Profile :

Thorough history taking, vital signs, height, weight and clinical examination done and were recorded from all the patients and entered in the proforma. Body mass index calculation was also done. Investigations like HBA1C, FBG, PPBG, renal function tests, fasting lipid profile and complete hemogram were entered in the proforma worksheet. 8 ml of blood was drawn in the fasting state and about 3 ml of blood in the post prandial state, sample was stored in -20^0c, used for investigations.

Intervention:

Each subject in group 2 was given Zinc tablets 50 mg per day and patients in Group 1 were given placebo tablets along with standard Oral Hypoglycemic Agents available in the hospital. Subjects are asked not to change their routine activities and not to take any vitamin supplementation other than the drug that was given. Subjects were also instructed to come after three months to collect OHA and supplementing drug and for review regarding any adverse effects and for monitoring of the therapy and periodic telephonic communication was made for proper compliance. Doses of Zinc tablets were chosen after review of literature on safe parameters.

At the end of six months history during the trial, state of well being, height, weight, FBG, PPBG, HBA1C, Lipid profile, serum Zinc

levels (as above), Haemogram, Urine analysis and micro albuminuria and fundus examination were recorded and data tabulated in proforma sheet.

GLUCOSE : Kit used-Cobas C311

Test principle : Enzymatic method with hexokinase

HB A1C

Hemoglobin A1c - determined by is Turbidimetric Inhibition Immunoassay (TINIA) for hemolyzed whole blood.

Calculation of Results

The analyzer automatically calculates the serum Zinc concentration in each sample by using calibration curve. The results are expressed in microg/dl.

STATISTICS

Descriptive statistics was done for all data and suitable statistical tests of comparison were done. Continuous variables were analysed with the Paired and Unpaired t test and categorical variables were analysed with the Chi-Square Test and Fisher Exact Test. Statistical significance was taken as $P < 0.05$. The data was analysed using EpiInfo software (7.1.0.6 version; Center for disease control, USA) and Microsoft Excel 2010.

Sample Size Calculation

Sample size was determined on the basis of a pilot study in which the reduction in HBA1 c levels was measured at 10%. We calculated a minimum sample size of 70 patients was required in each group, assuming a type 1 error (two-tailed) of 0.05 and a margin of error of 10%. Therefore, the final sample selected was n=70 in Group 1 and n=70 in Group 2.

The formula for calculating sample size is

$$\mathbf{n} = \frac{\mathbf{t^2} \times \mathbf{p(1-p)}}{\mathbf{m^2}}$$

Description:

n = required sample size

t = confidence level at 95% (standard value of 1.96)

p = estimated prevalence of malnutrition in the project area

m = margin of error at 10% (standard value of 0.05)

$$\mathbf{n} = \frac{\mathbf{(1.96)^2} \times \mathbf{0.1(1-0.9)}}{\mathbf{(0.05)^2}}$$

$$\mathbf{n} = \frac{\mathbf{3.8146} \times \mathbf{0.09}}{\mathbf{0.025}}$$

= 138 = 69 per group

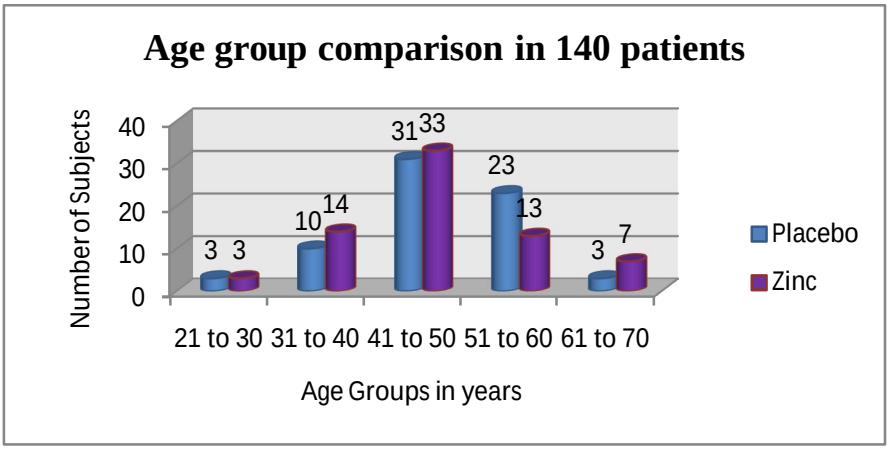
RESULTS

140 patients were included after meeting eligibility criteria in the study in two groups and followed for a period of about one year . BMI, FBG, PPBG, HBA1C, Serum Zinc Levels, Haemogram, Urine Routine analysis and microalbuminuria were done and tabulated in the worksheet and analyzed. Results are as follows:

Treatment Groups

Treatment Groups	Name of Group	Treatment	Number of Subjects
Group 1	Placebo	Placebo supplementation + OHA in newly detected type 2 diabetic patients	70
Group 2	Zinc	Zinc supplementation + OHA in newly detected type 2 diabetic patients	70

Figure 5.1 : Age group comparison between patients



Lowest age in the study is 29 years and highest age in the study is 67.

TABLE 5.1 AGE GROUP DISTRIBUTION BETWEEN GROUPS

Age Distribution	Placebo	%	Placebo	%
21 to 30	3	4.29	3	4.29
31 to 40	10	14.29	14	20.00
41 to 50	31	44.29	33	47.14
51 to 60	23	32.86	13	18.57
61 to 70	3	4.29	7	10.00
Total	70	100	70	100

TABLE 5.2 MEAN AGE DISTRIBUTION BETWEEN GROUPS

Age (years)	Placebo group	Zinc group
N	70	70
Mean	48.17143	47.27143
SD	8.16669	8.890512
P value Unpaired t test		0.533

Mean age for placebo group is 48.17. Mean age for Zinc group is 47.27.p value for age difference between the groups is 0.533 ($p<0.05$) which is statistically insignificant.

Figure 5.2 Gender distribution between groups

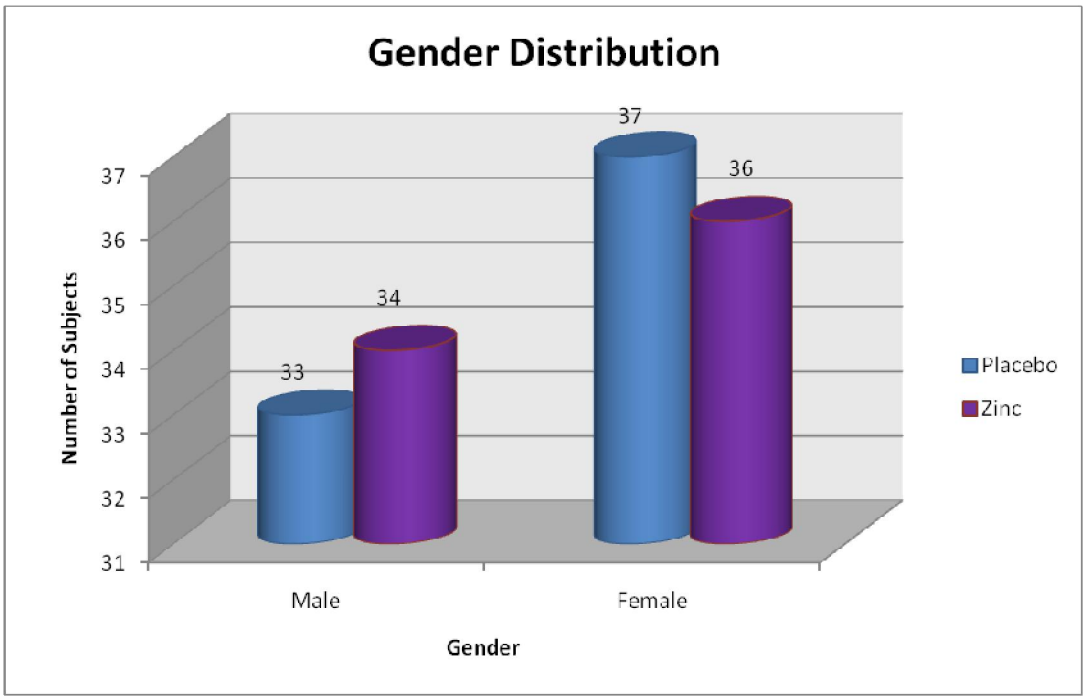


TABLE 5.3 SEX DISTRIBUTION BETWEEN GROUPS

Gender Distribution	Placebo	%	Zinc	%
Male	33	47.14	34	48.57
Female	37	52.86	36	51.43
Total	70	100	70	100

In this study about equal distribution is noted between males and females.

TABLE 5.4 GENDER DISTRIBUTION BETWEEN GROUPS

Gender Distribution	Placebo	Zinc
Male	33	34
Female	37	36
Total	70	70
Chi squared	0.029	
Degrees of freedom	1	
P value Chi-square test without Yates correction	0.8657	

p value for sex between the two groups by Chi square is p=0.8657 which is statistically insignificant. Since age and gender is not statistically significant, it means that there is no difference between the groups. In other words the groups contain subjects with the same basic demographic characteristics.

Figure 5.3 Comparison of Pre BMI between groups

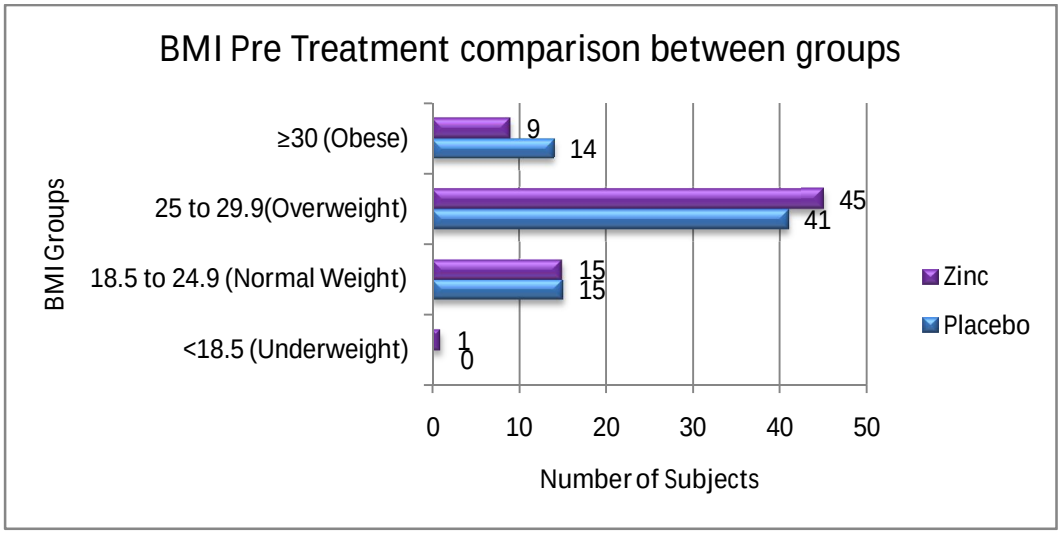


TABLE 5.5 COMPARISON OF PRE BMI TREATMENT BETWEEN GROUPS

BMI Pre Treatment	Placebo	%	Zinc	%
<18.5 (Underweight)	0	0.00	1	1.43
18.5 to 24.9 (Normal Weight)	15	21.43	15	21.43
25 to 29.9 (Overweight)	41	58.57	45	64.29
≥30 (Obese)	14	20.00	9	12.86
Total	70	100	70	100

TABLE 5.6 COMPARISON OF MEAN BMI PRE TREATMENT IN BOTH GROUPS

BMI Pre Treatment	Placebo	Zinc
N	70	70
Mean	27.74514	27.97357
SD	3.050923	2.99396
P value Unpaired t test	0.131	

p value for BMI (pre treatment)between the two groups by unpaired t test is 0.131 which is statistically insignificant.

Figure 5.4 Comparison of BMI post treatment between groups

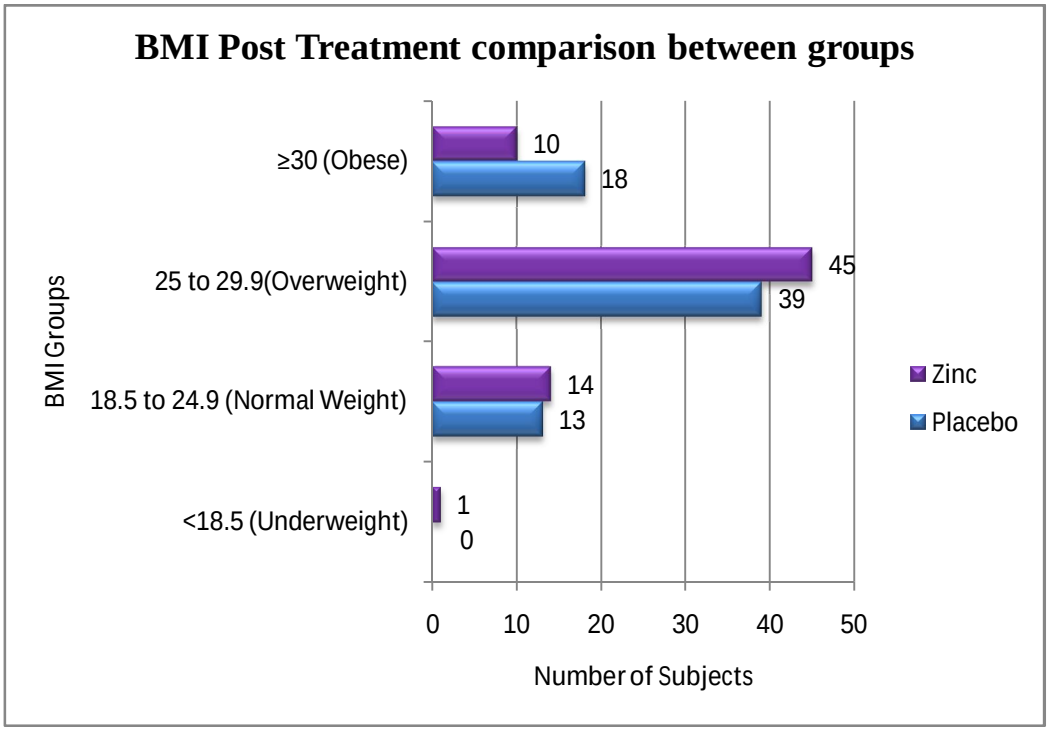


TABLE 5.7 COMPARISON OF BMI POST TREATMENT BETWEEN BOTH GROUPS

BMI Post Treatment	Placebo	%	Zinc	%
<18.5 (Underweight)	0	0.00	1	1.43
18.5 to 24.9 (Normal Weight)	13	18.57	14	20.00
25 to 29.9(Overweight)	39	55.71	45	64.29
≥30 (Obese)	18	25.71	10	14.29
Total	70	100	70	100

TABLE 5.8 COMPARISON OF MEAN BMI POST TREATMENT IN BOTH GROUPS

BMI Post Treatment	Placebo	Zinc
N	70	70
Mean	27.97357	26.99729
SD	2.99396	3.770757
P value Unpaired t test	0.092167	

p value for BMI (post treatment)between the two groups by unpaired t test is 0.092167 which is statistically insignificant.

Hence age, sex , BMI during start and end of study doesn't interfere with the variables to be measured.

Figure 5.5 Comparison of FBG pre treatment in both groups

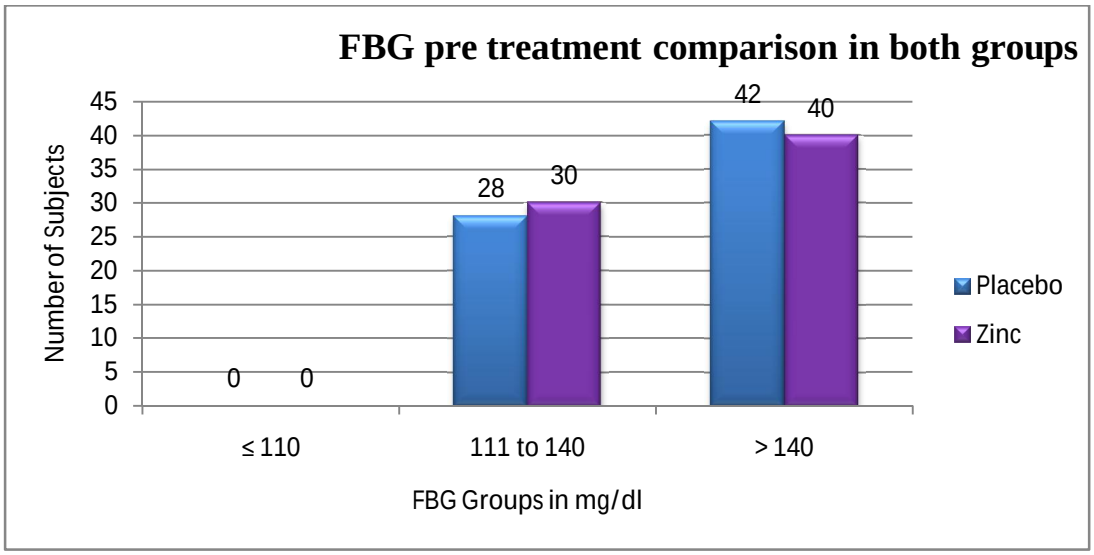


TABLE 5.9 FBG PRE TREATMENT (%) IN BOTH GROUPS

FBG Pre Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 110	0	0.00	0	0.00
111 to 140	28	40.00	30	42.86
> 140	42	60.00	40	57.14
Total	70	100	70	100

Most of the subjects in both groups have >140 mg/dl.

TABLE 5.10 COMPARISON OF MEAN FBG AT PRE TREATMENT IN BOTH GROUPS

FBG Pre Treatment	Placebo	Zinc
N	70	70
Mean	154.8	153.9
SD	22.314	30.021
P value Unpaired t test	0.828	

Mean FBG (pre treatment) in placebo group is 154.8.Mean FBG (pre treatment) in Zinc supplemented group is 153.9. p value for FBG(pre treatment)between the two groups by unpaired t test is 0.828 which is statistically insignificant.

Figure 5.6 Comparison of FBG post treatment in both groups

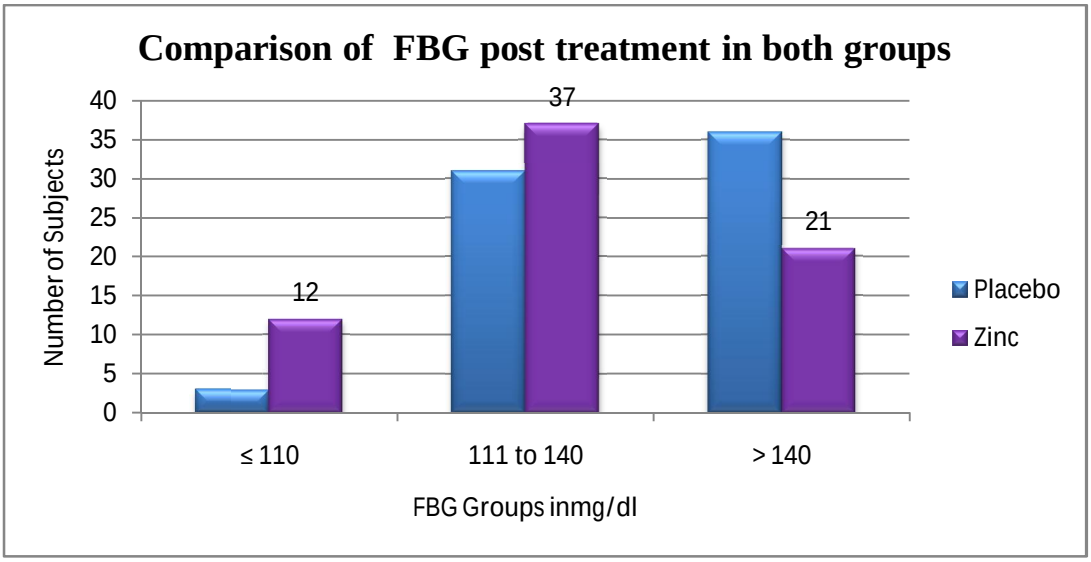


TABLE 5.11 FBG POST TREATMENT (%) IN BOTH GROUPS

FBG Post Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 110	3	4.29	12	17.14
111 to 140	31	44.29	37	52.86
> 140	36	51.43	21	30.00
Total	70	100	70	100

TABLE 5.12 COMPARISON OF MEAN FBG AT POST TREATMENT IN BOTH GROUPS

FBG Post Treatment	Placebo	Zinc
N	70	70
Mean	145.3	131.8
SD	24.332	21.888
P value Unpaired t test	0.0008	

Mean FBG (post treatment) in placebo group is 145.3. Mean FBG (post treatment) in 131.8. p value for FBG(post treatment)between the two groups by unpaired t test is 0.0008 which is statistically significant.

The difference within the Zinc supplementation group (pre and Post intervention) and fasting blood glucose levels is considered to be statistically significant since $p < 0.05$(0.0008).

Figure 5.7 Correlation chart between Serum Zinc and FBG (pretreatment)

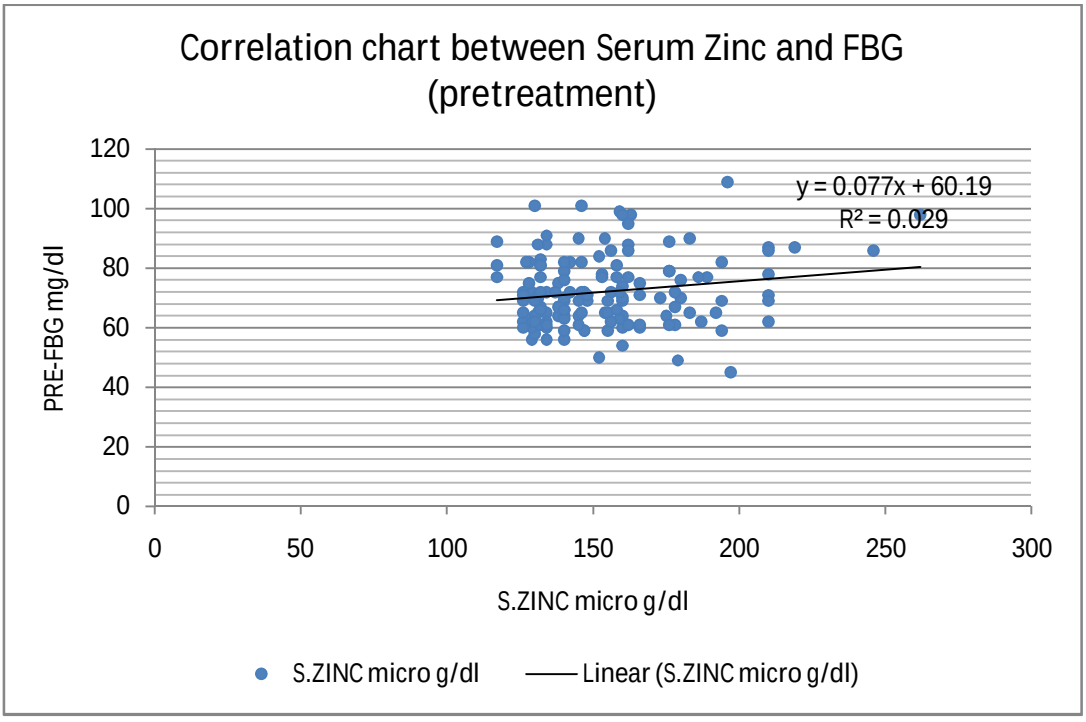


TABLE : 5.13 PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND FBG (PRETREATMENT)

Pearson's Correlation	PRE-FBG mg/dl	Interpretation
S.ZINC micro g/dl	0.17	Weak positive correlation
P value	0.03	Significant

P value by Pearson's correlation between FBG and S.Zinc levels is 0.03 which is statistically significant. There is a weak positive correlation is seen between FBG (pre treatment) and Serum Zinc levels.

Figure 5.8 Correlation chart between Serum Zinc and FBG (post treatment)

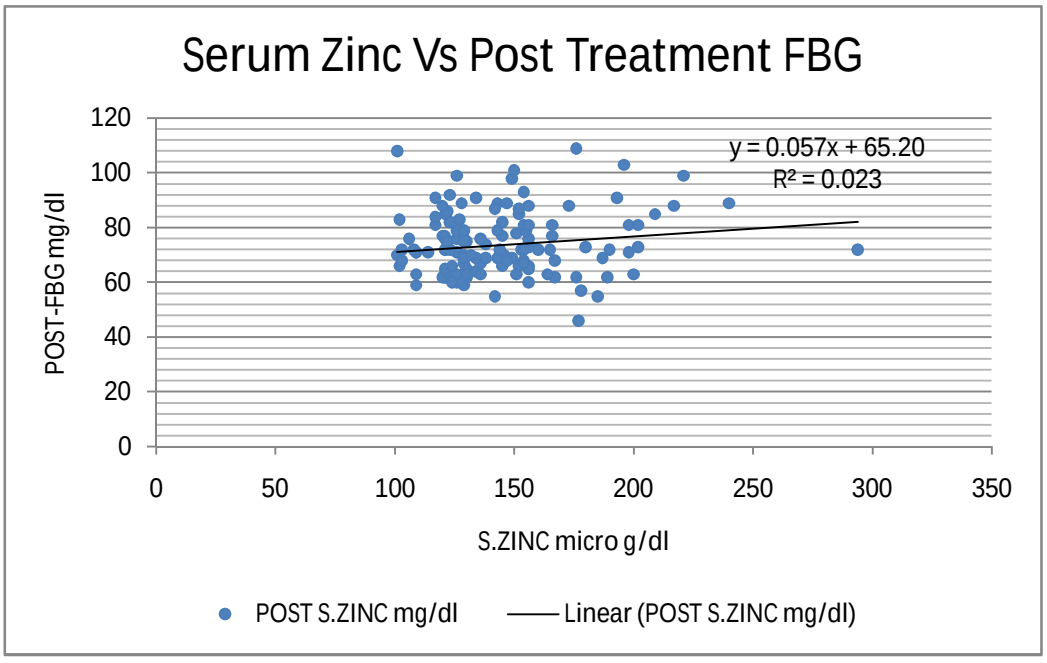


TABLE 5.14: PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND POST -FBG

Pearson's Correlation	POST-FBG mg/dl	Interpretation
POST S.ZINC mg/dl	0.152	Weak positive correlation
P value	0.0001	Significant

P value by Pearson's correlation between FBG and S.Zinc levels is 0.0001 which is statistically significant. There is a weak positive correlation is seen between FBG (post treatment) and Serum Zinc levels.

Figure 5.9 PPBG pre treatment comparison between groups

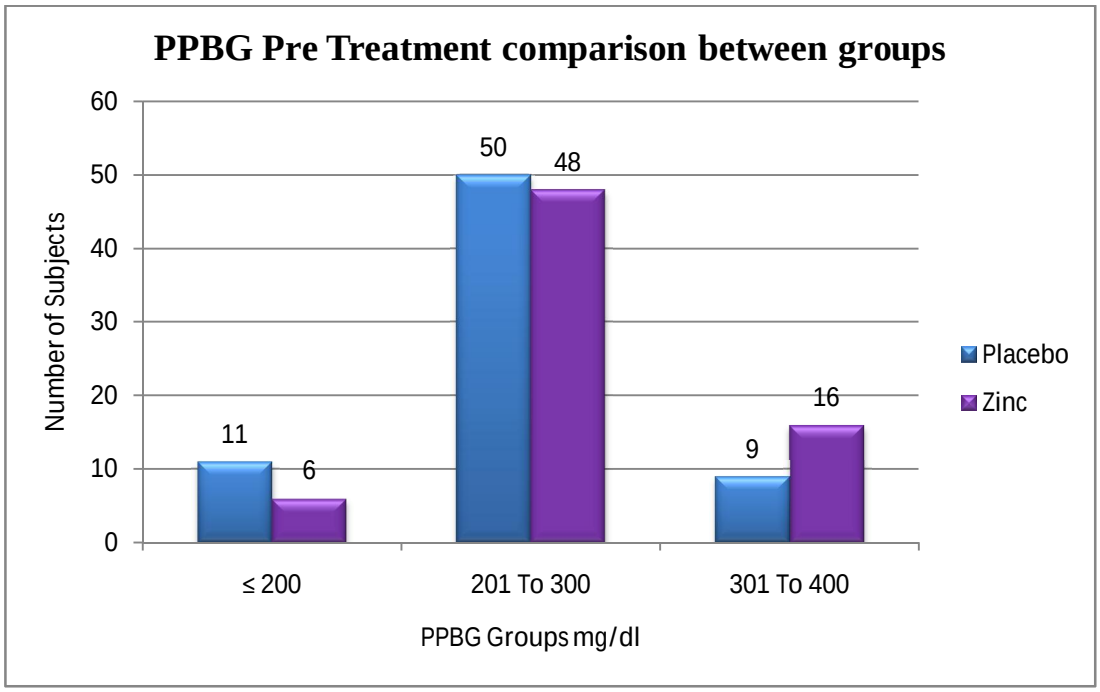


TABLE 5.15 PPBG PRE TREATMENT (%) IN BOTH GROUPS

PPBG Pre Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 200	11	15.71	6	8.57
201 To 300	50	71.43	48	68.57
301 To 400	9	12.86	16	22.86
Total	70	100	70	100

TABLE 5.16 COMPARISON OF MEAN AT PPBG- PRE TREATMENT IN BOTH GROUPS

PPBG Pre Treatment (mg/dl)	Placebo	Zinc
N	70	70
Mean	250.2	266.18
SD	44.66513	59.718
P value Unpaired t test	0.075	

Mean PPBG before treatment in placebo group is 250.2. Mean PPBG before treatment in Zinc supplemented group is 266.18. p value for PPBG(pre treatment)between the two groups by unpaired t test is 0.075 which is statistically insignificant.

Figure 5.10 PPBG- post treatment comparison between groups

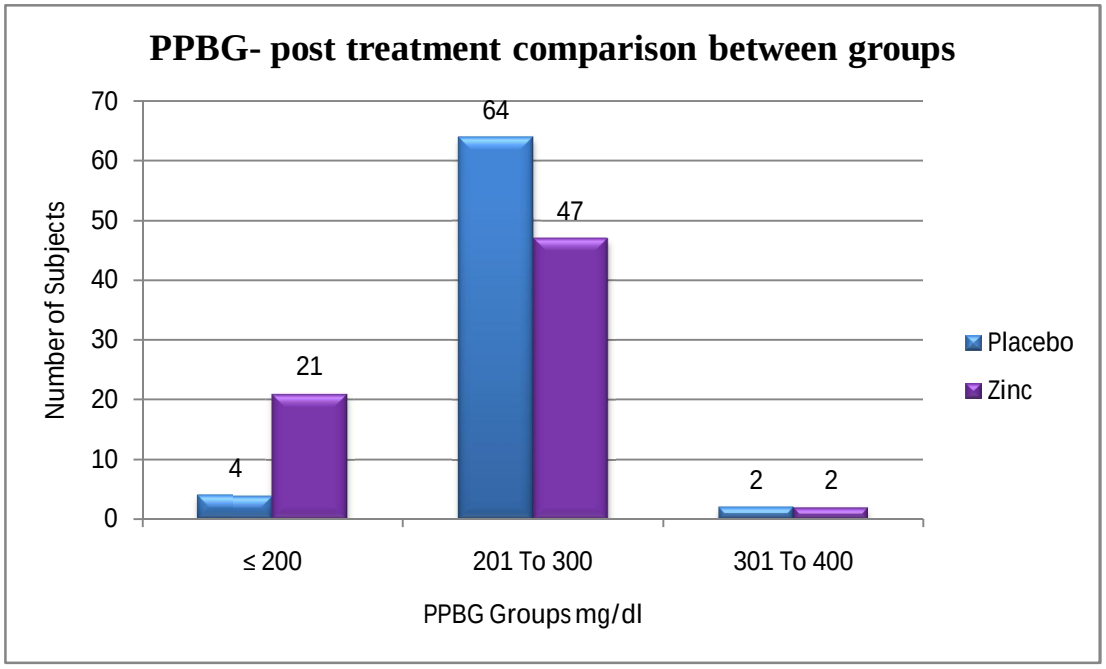


TABLE 5.17 PPBG-POST TREATMENT (%) IN BOTH GROUPS

PPBG Post Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 200	4	5.71	21	30.00
201 To 300	64	91.43	47	67.14
301 To 400	2	2.86	2	2.86
Total	70	100	70	100

TABLE 5.18.COMPARISON OF MEAN PPBG AT POST TREATMENT IN BOTH GROUPS

PPBG Post Treatment (mg/dl)	Placebo	Zinc
N	70	70
Mean	234.2714	221.0143
SD	31.04224	40.80405
P value Unpaired t test		0.032*

*Significant

p value for PPBG(post treatment)between the two groups by unpaired t test is 0.032 which is statistically significant. The difference within the treatment groups (pre and Post intervention) and post prandial blood glucose levels is considered to be statistically significant since $p < 0.05$.

Figure 5.11 Correlation chart between Serum Zinc and PPBG (pretreatment)

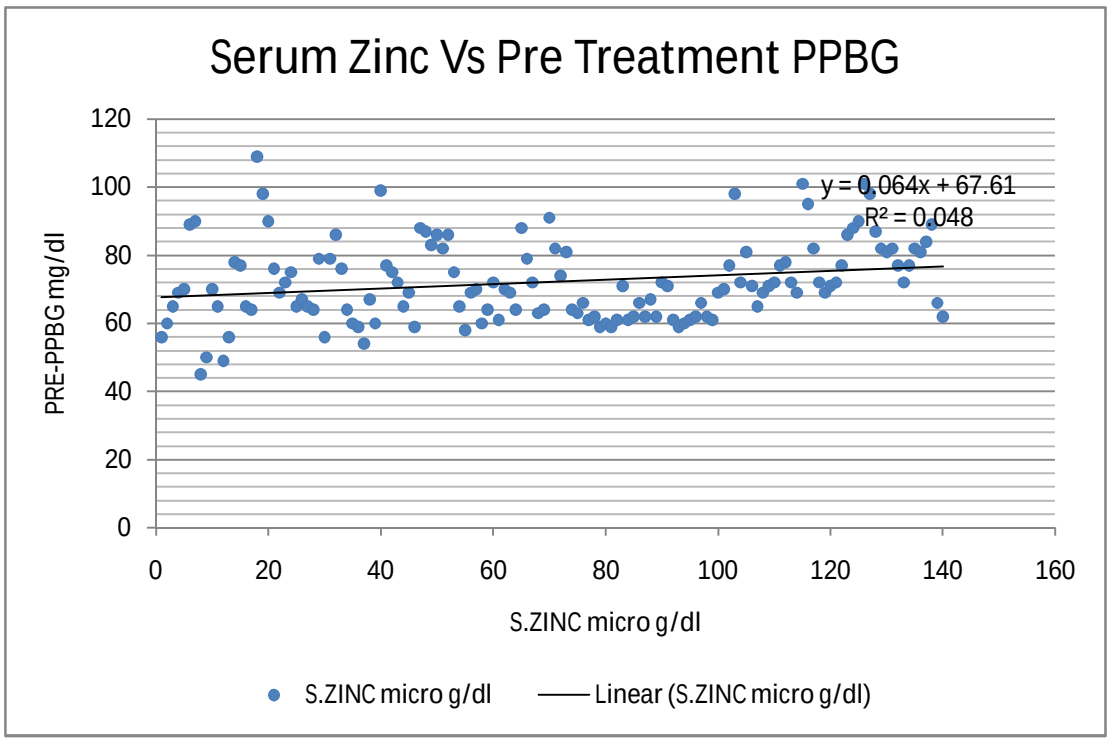


TABLE 5.19 PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND PPBG (PRETREATMENT)

Pearson's Correlation	PRE-PPBG mg/dl	Interpretation
S.ZINC micro g/dl	0.18	Weak positive correlation
P value	0.1487	Not significant

P value by pearson's correlation between PPBG and S.Zinc levels is 0.1487 which is statistically not significant. There is a weak positive correlation is seen between PPBG (pre treatment) and Serum Zinc levels.

Figure 5.12 Correlation chart between Serum Zinc and PPBG (post treatment)

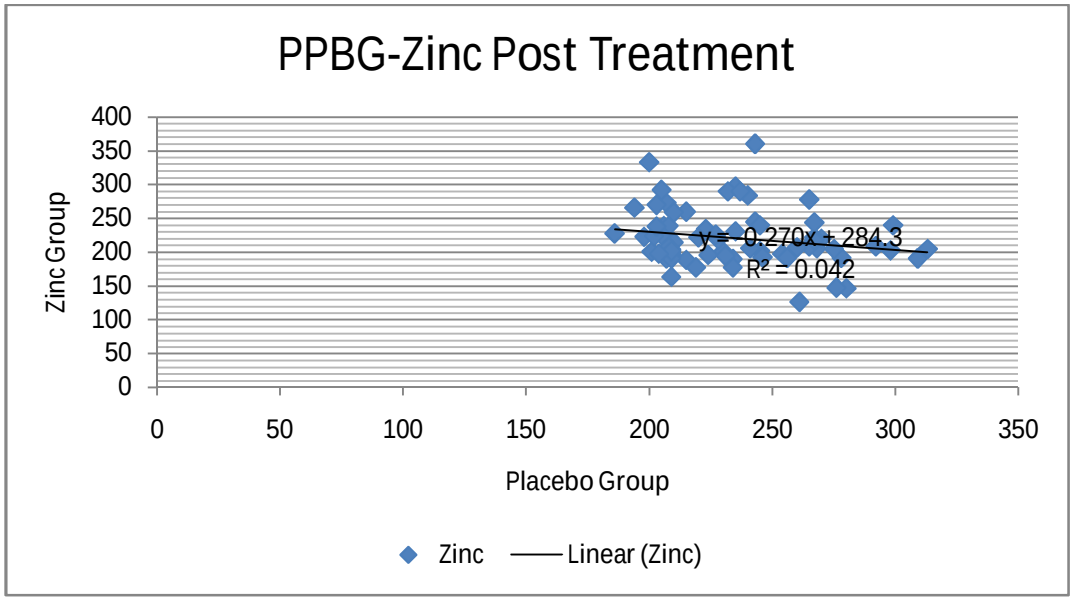


TABLE 5.20 PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND PPBG (POST TREATMENT)

Pearson's Correlation	Placebo	Interpretation
Zinc	-0.20575	Weak Negative correlation
P value	0.0003***	Highly significant

*** Highly significant

P value by Pearson's correlation between PPBG and S.Zinc levels is 0.0003 which is statistically significant. There is a weak negative correlation is seen between PPBG (post treatment) and Serum Zinc levels.

Figure 5.13 Comparison of HBA1c Pre treatment in both groups

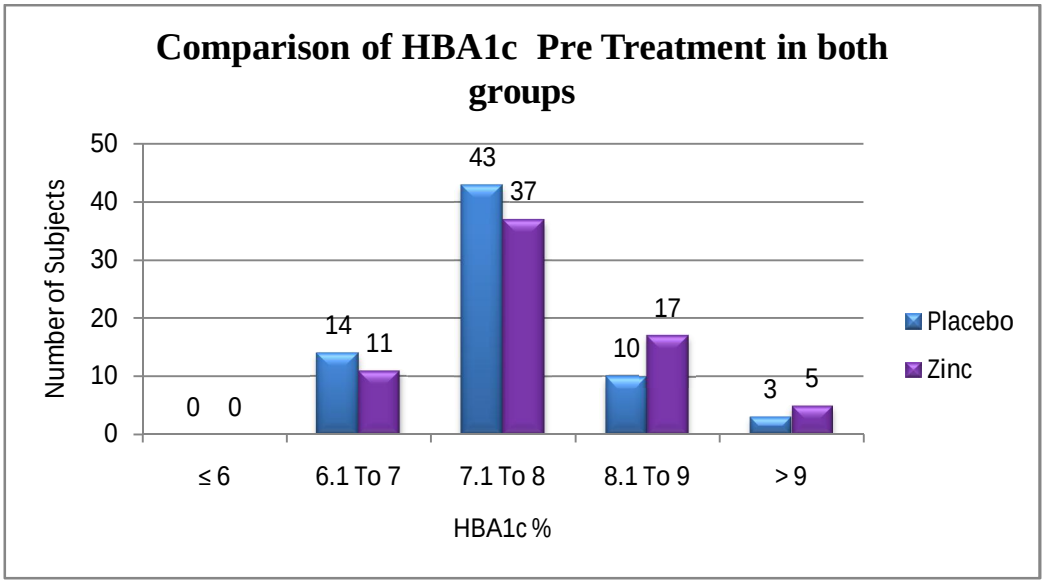


TABLE 5.21 COMPARISON OF HBA1C (%) BETWEEN PLACEBO AND ZINC

HBA1c Pre Treatment	Placebo	%	Zinc	%
≤ 6	0	0.00	0	0.00
6.1 To 7	14	20.00	11	15.71
7.1 To 8	43	61.43	37	52.86
8.1 To 9	10	14.29	17	24.29
> 9	3	4.29	5	7.14
Total	70	100	70	100

TABLE 5.22 COMPARISON OF MEAN HBA1C PRE TREATMENT BETWEEN BOTH GROUPS

HBA1c Pre Treatment	Placebo	Zinc
N	70	70
Mean	7.547	7.788
SD	0.617395	0.958129
P value Unpaired t test		0.079

Mean HBA1c level for placebo group is 7.547. Mean HBA1c level for Zinc supplemented group is 7.788. p value for HBA1c(pre treatment)between the two groups by unpaired t test is 0.079 which is statistically not significant.

Figure 5.14 Comparison of HBA1c post treatment between both groups

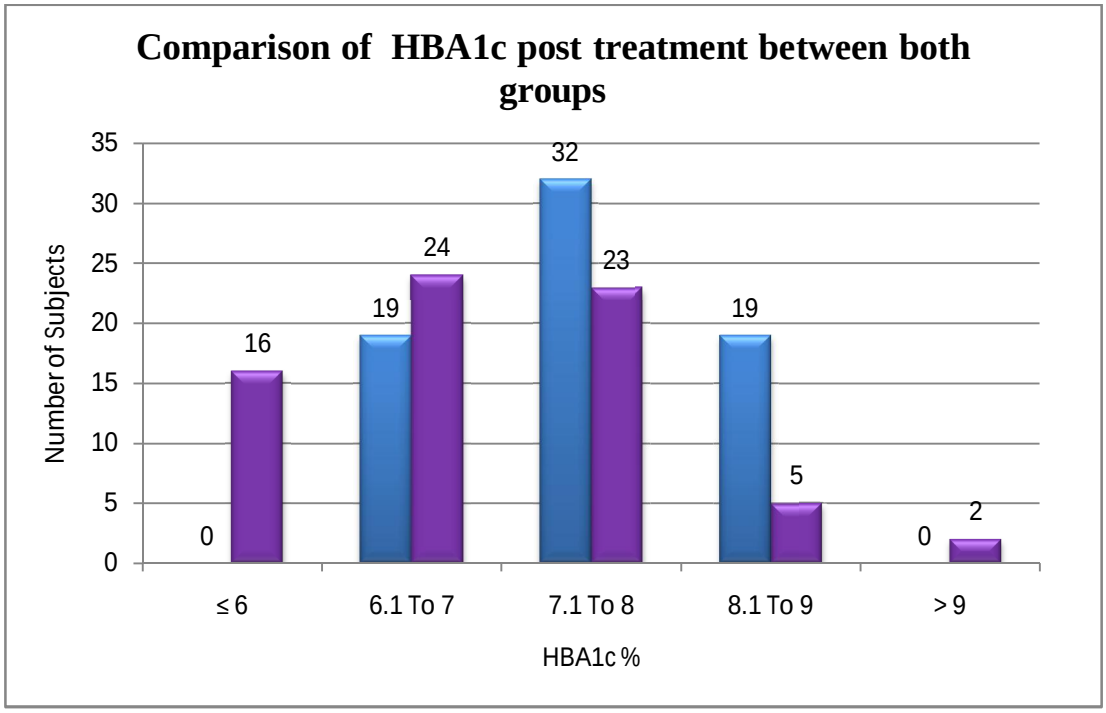


TABLE 5.23 HBA1C LEVELS POST TREATMENT (%) IN BOTH GROUPS

HBA1c Post Treatment	Placebo	%	Zinc	%
≤ 6	0	0.00	16	22.86
6.1 To 7	19	27.14	24	34.29
7.1 To 8	32	45.71	23	32.86
8.1 To 9	19	27.14	5	7.14
> 9	0	0.00	2	2.86
Total	70	100	70	100

TABLE 5.24 COMPARISON OF MEAN HBA1C LEVEL POST TREATMENT BETWEEN GROUPS

HBA1c Post Treatment	Placebo	Zinc
N	70	70
Mean	7.415714	6.861714
SD	0.731018	1.032401
P value Unpaired t test	0.0004***	

*** Highly significant

p value by unpaired t test between the two groups is 0.0004 which is statistically significant. There is significant reduction in HBA1c levels in Zinc supplemented group when compared to placebo. The difference within the treatment groups (pre and Post intervention) and HBA1c levels is considered to be statistically significant since $p < 0.05(0.0004)$.

Figure 5.15 Correlation chart between Serum Zinc and HBA1c (pretreatment)

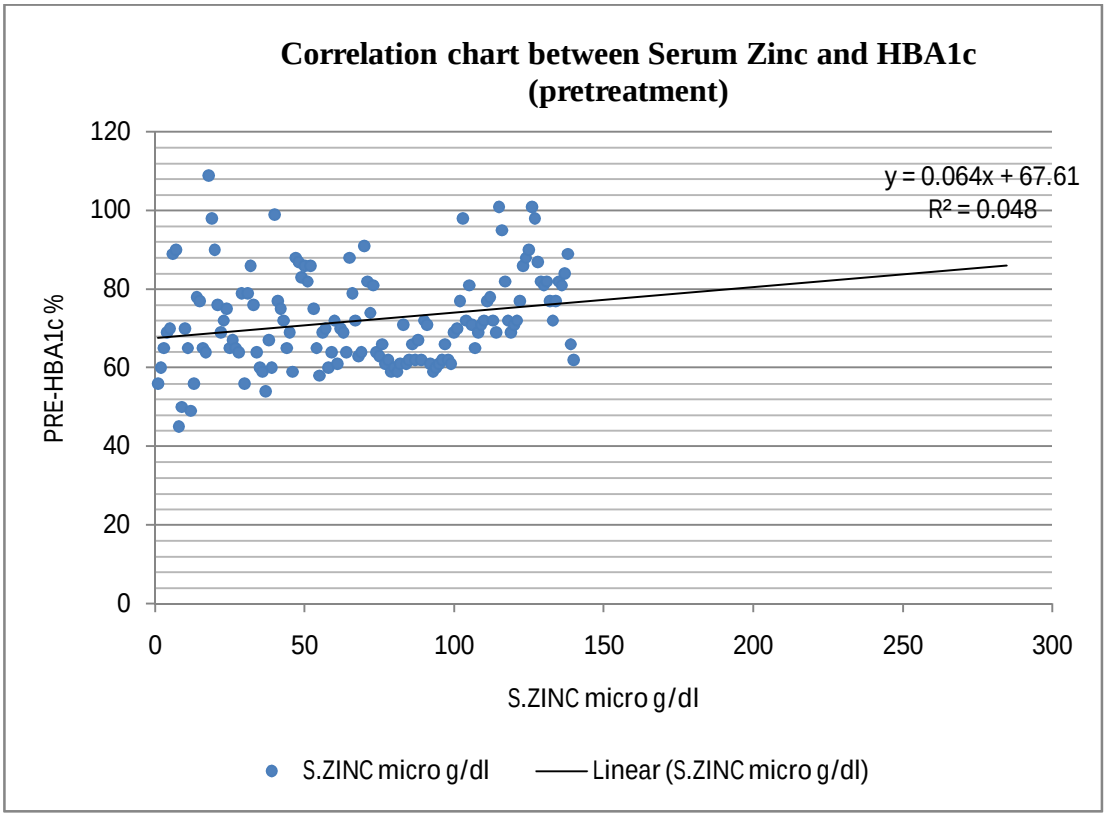


TABLE 5.25 PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND HBA1C (PRE TREATMENT)

Pearson's Correlation	PRE-HBA1c %	Interpretation
S.ZINC micro g/dl	0.1725	Weak positive correlation
P value	0.1881	Not significant

P value by pearson's correlation between HBA1c and S.Zinc levels is 0.1881 which is statistically not significant. There is a weak positive correlation is seen between HBA1c (pre treatment) and Serum Zinc levels.

Figure 5.16 Correlation chart between Serum Zinc and HBA1c (post treatment)

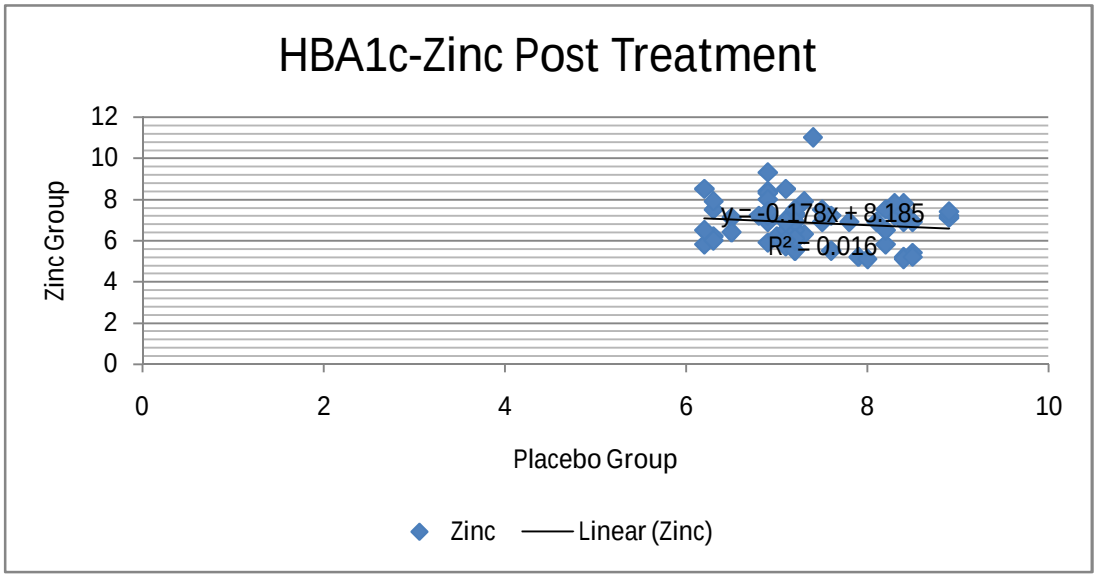


TABLE 5.26 PEARSON'S CORRELATION COEFFICIENT BETWEEN SERUM ZINC AND HBA1C (POST TREATMENT)

Pearson's Correlation	HBA1c-Zinc Post Treatment	Interpretation
Zinc	-0.12639	Weak negative correlation
P value	0.0001***	Highly significant

*** Highly significant

P value by Pearson's correlation between HBA1c and S.Zinc levels is 0.0001 which is statistically significant. There is a weak negative correlation is seen between HBA1c (pre treatment) and Serum Zinc levels.

Figure 5.17 Comparison of LDL pre treatment between both groups

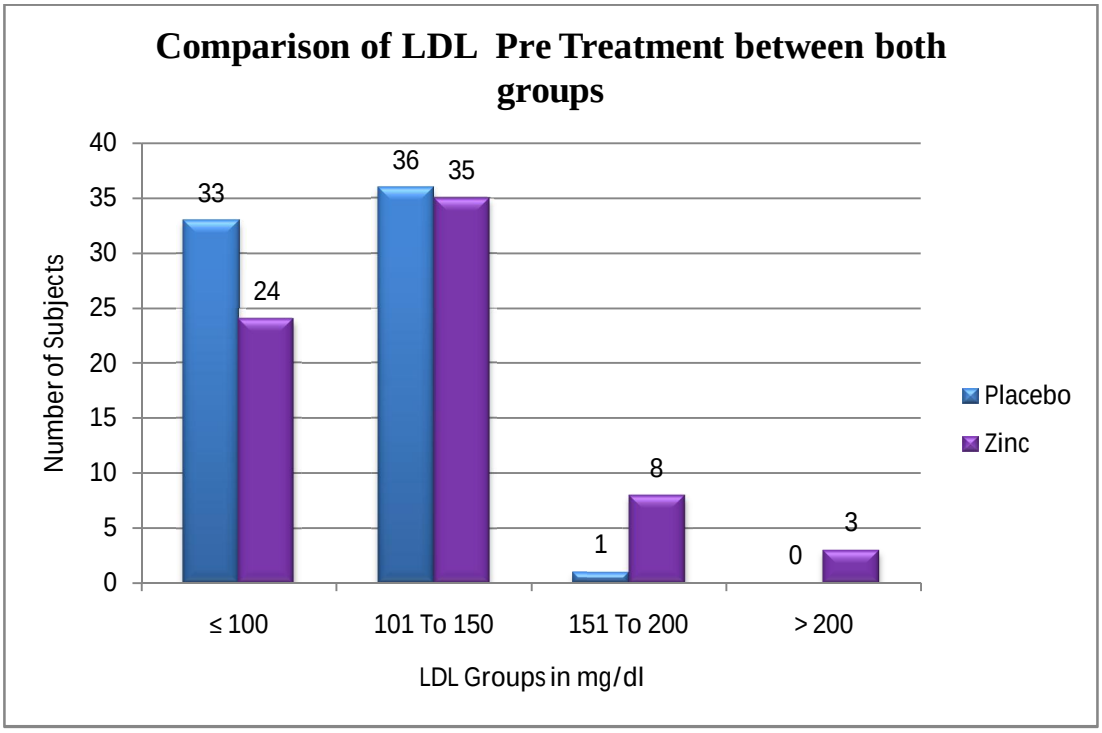


TABLE 5.27 COMPARISON OF LDL PRE TREATMENT IN BOTH GROUPS

LDL Pre Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 100	33	47.14	24	34.29
101 To 150	36	51.43	35	50.00
151 To 200	1	1.43	8	11.43
> 200	0	0.00	3	4.29
Total	70	100.00	70	100.00

TABLE 5.28 COMPARISON OF MEAN LDL PRE TREATMENT IN BOTH GROUPS

LDL Pre Treatment	Placebo	Zinc
N	70	70
Mean	105.496	95.64
SD	24.92604	16.7486
P value Unpaired t test		0.25515

Mean LDL pre treatment placebo group is 105.4. Mean LDL pre treatment Zinc group is 95.64. p value for LDL between the two groups is 0.255 which is statistically insignificant.

Figure 5.18 Comparison of LDL post treatment in both groups

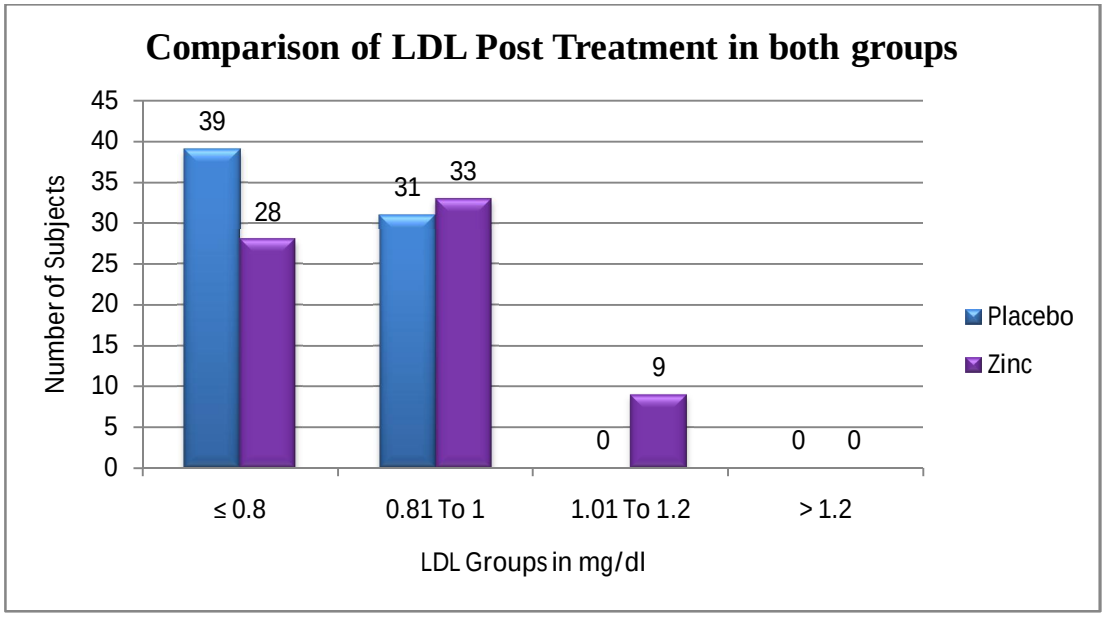


TABLE 5.29 COMPARISON OF LDL POST TREATMENT IN BOTH GROUPS

LDL Post Treatment (mg/dl)	Placebo	%	Zinc	%
≤ 0.8	39	55.71	28	40.00
0.81 To 1	31	44.29	33	47.14
1.01 To 1.2	0	0.00	9	12.86
> 1.2	0	0.00	0	0.00
Total	70	100	70	100

TABLE 5.30 COMPARISON OF MEAN LDL POST TREATMENT IN BOTH GROUPS

LDL Post Treatment	Placebo	Zinc
N	**70**	**70**
Mean	95.64	109.37
SD	16.7486	27.36421
P value Unpaired t test		0.50500

The difference between the treatment groups and serum LDL levels is considered to be statistically not significant since p > 0.05. So the effect of Zinc supplementation on LDL levels in type 2 diabetic patients is not significant.

Figure 5.19 Comparison of TG pre treatment in both groups

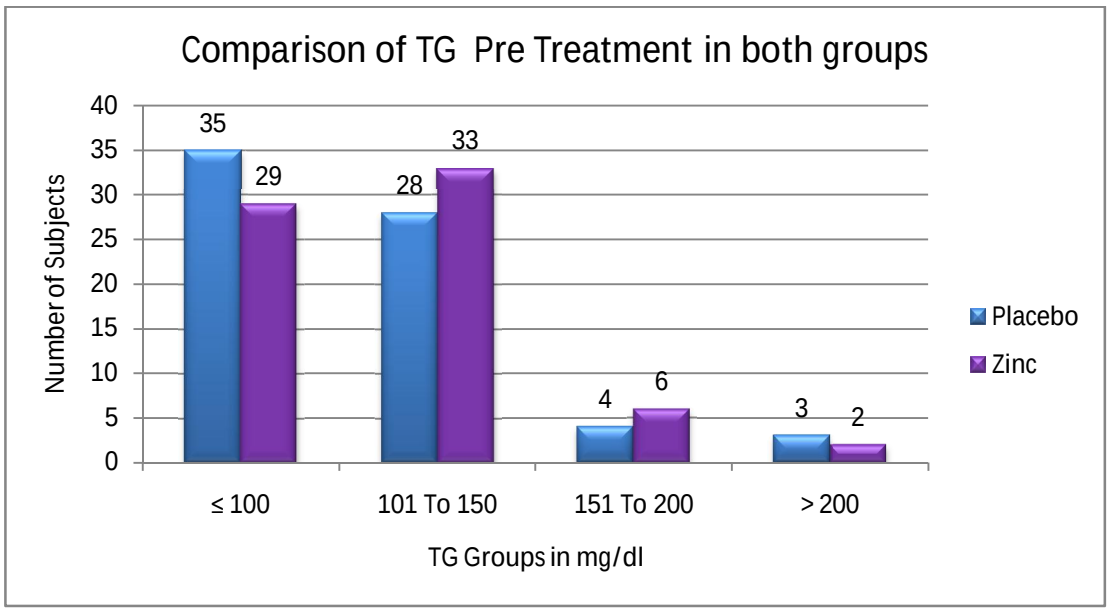


TABLE 5.31 COMPARISON OF TG PRE TREATMENT IN BOTH GROUPS

TG Pre Treatment	Placebo	%	Zinc	%
≤ 100	35	50.00	29	41.43
101 To 150	28	40.00	33	47.14
151 To 200	4	5.71	6	8.57
> 200	3	4.29	2	2.86
Total	70	100.00	70	100.00

TABLE 5.32 COMPARISON OF MEAN TG PRE TREATMENT IN BOTH GROUPS

TG Pre Treatment	**Placebo**	**Zinc**
N	70	70
Mean	115.2986	109.0286
SD	40.48	32.35
P value Unpaired t test	0.922	

Mean TG pre treatment placebo group is 115.2. Mean TG pre treatment Zinc group is 109.02. p value for TG between the two groups is 0.922 which is statistically insignificant

Figure 5.20 Comparison of TG post treatment in both groups

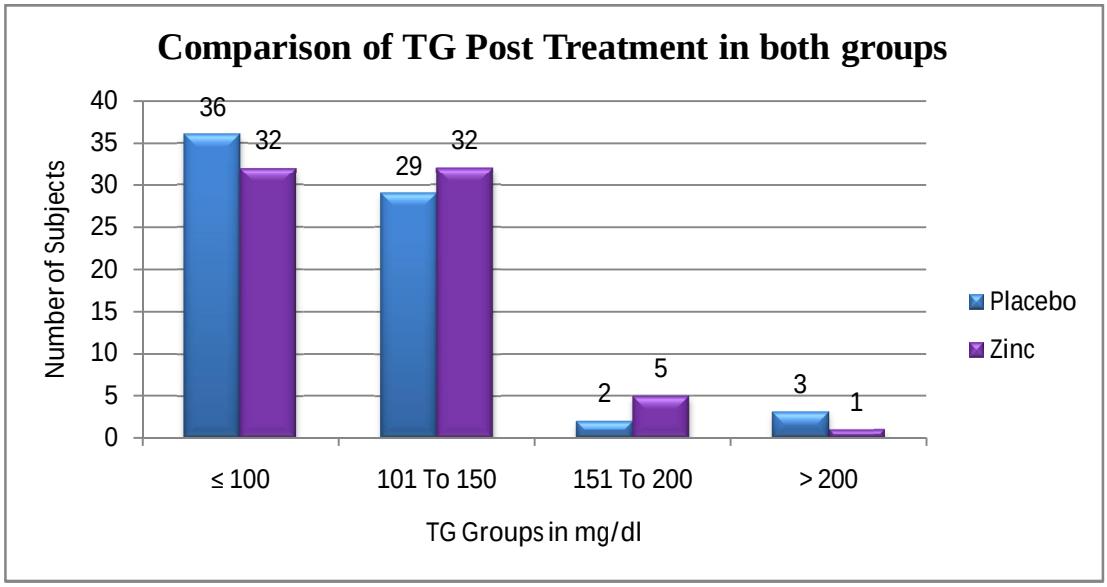


TABLE 5.33 COMPARISON OF TG POST TREATMENT IN BOTH GROUPS

TG post Treatment	Placebo	%	Zinc	%
≤ 100	36	51.43	32	45.71
101 To 150	29	41.43	32	45.71
151 To 200	2	2.86	5	7.14
> 200	3	4.29	1	1.43
Total	70	100	70	100

TABLE 5.34 COMPARISON OF MEAN TG POST TREATMENT IN BOTH GROUPS

TG Post Treatment	Placebo	Zinc
N	70	70
Mean	109.0286	112.1514
SD	32.35653	30.44071
P value Unpaired t test	0.55741	

The difference within the treatment groups (pre and Post intervention) and serum triglycerides levels is considered to be not statistically significant since p > 0.05 (0.55741).

FIGURE 5.21 COMPARISON OF HDL (MG/DL) PRE TREATMENT IN BOTH GROUPS

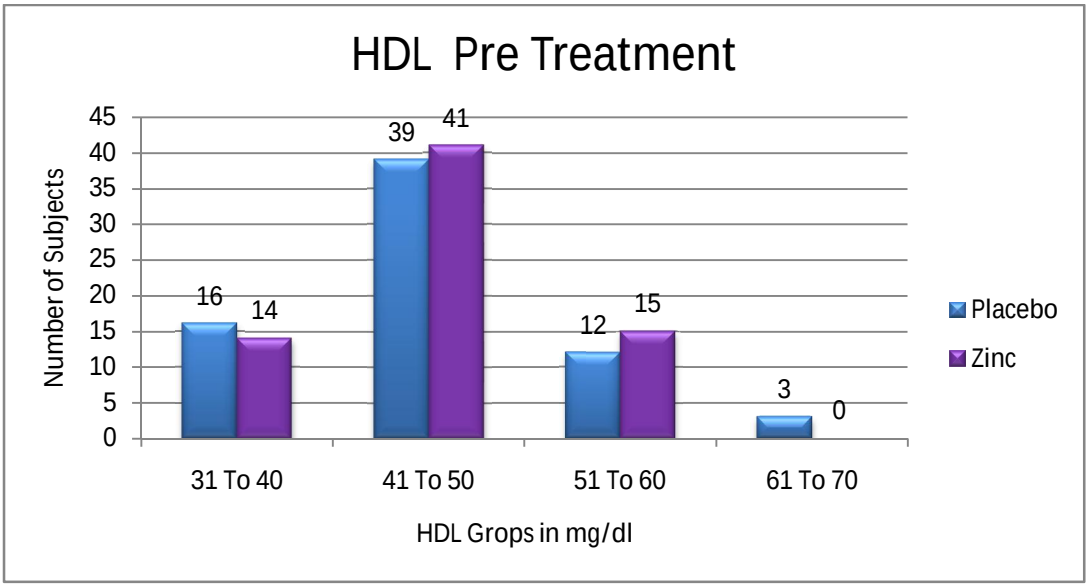


TABLE 5.35 COMPARISON OF HDL PRE TREATMENT IN BOTH GROUPS

HDL Pre Treatment	Placebo	%	Zinc	%
31 To 40	16	22.86	14	20.00
41 To 50	39	55.71	41	58.57
51 To 60	12	17.14	15	21.43
61 To 70	3	4.29	0	0.00
Total	70	100.00	70	100.00

TABLE 5.36 COMPARISON OF MEAN HDL AT PRE TREATMENT IN BOTH GROUPS

HDL Pre Treatment	Placebo	Zinc
N	70	70
Mean	46.54429	50.35429
SD	7.265097	7.159076
P value Unpaired t test	0.528109	

Mean HDL pre treatment placebo group is 46.54. Mean HDL pre treatment Zinc group is 50.35. p value for HDL between the two groups is 0.5281 which is statistically insignificant

Figure 5.22 Comparison of HDL post treatment in both groups

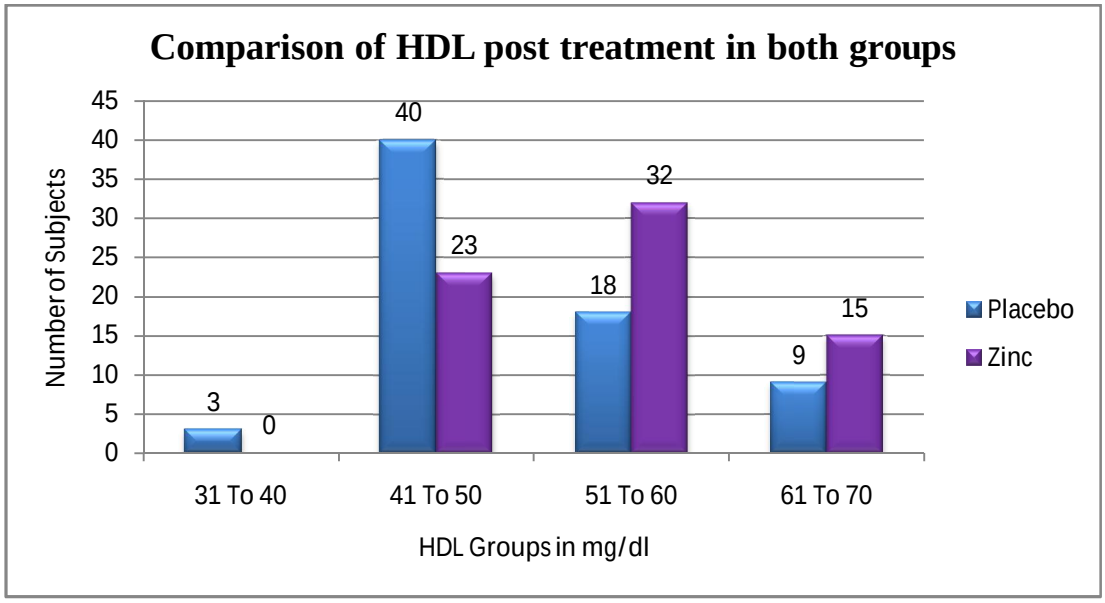


TABLE 5.37 COMPARISON OF HDL (MG/DL) AT POST TREATMENT IN BOTH GROUPS

HDL Post Treatment	Placebo	%	Zinc	%
31 To 40	3	4.29	0	0.00
41 To 50	40	57.14	23	32.86
51 To 60	18	25.71	32	45.71
61 To 70	9	12.86	15	21.43
Total	70	100	70	100

TABLE 5.38 COMPARISON OF MEAN HDL AT POST TREATMENT IN BOTH GROUPS

HDL Post Treatment	Placebo	Zinc
N	70	70
Mean	50.35429	53.80571
SD	7.159076	7.205792
P value Unpaired t test	0.5150	

The difference between the treatment groups and serum HDL levels is considered to be not statistically significant since p > 0.05(0.5150).

Figure 5.23 Comparison of CHL pre treatment in both groups

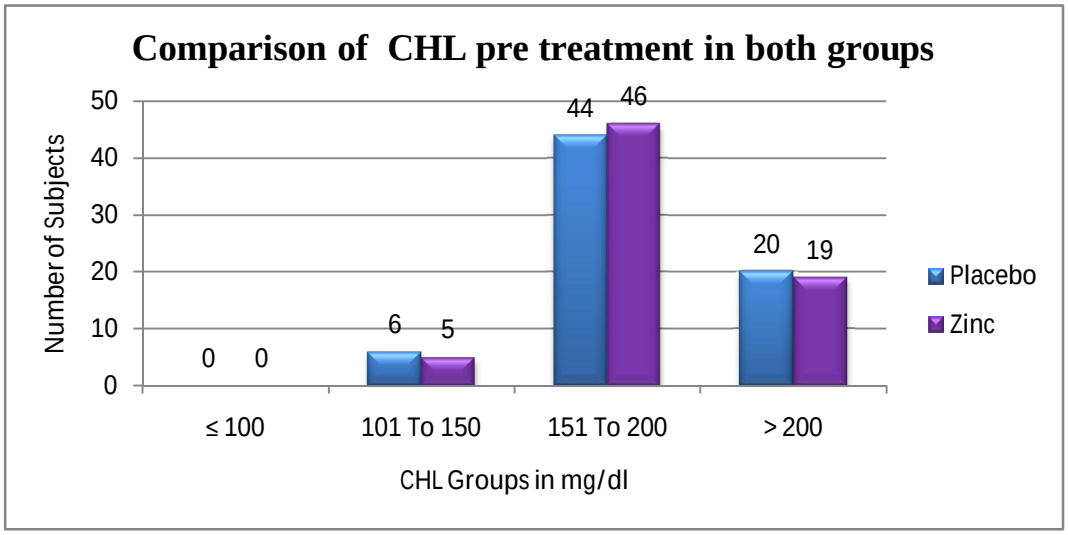


TABLE 5.39 COMPARISON OF CHL (MG/DL) AT PRE TREATMENT IN BOTH GROUPS

CHL Pre Treatment	Placebo	%	Zinc	%
≤ 100	0	0.00	0	0.00
101 To 150	6	8.57	5	7.14
151 To 200	44	62.86	46	65.71
> 200	20	28.57	19	27.14
Total	70	100.00	70	100.00

TABLE 5.40 COMPARISON OF MEAN CHL PRE TREATMENT IN BOTH GROUPS

CHL Pre Treatment	Placebo	Zinc
N	70	70
Mean	187.7434	172.1614
SD	29.96465	24.83353
P value Unpaired t test	0.785016	

Figure 5.24 Comparison of CHL (mg/dl) at post treatment in both groups

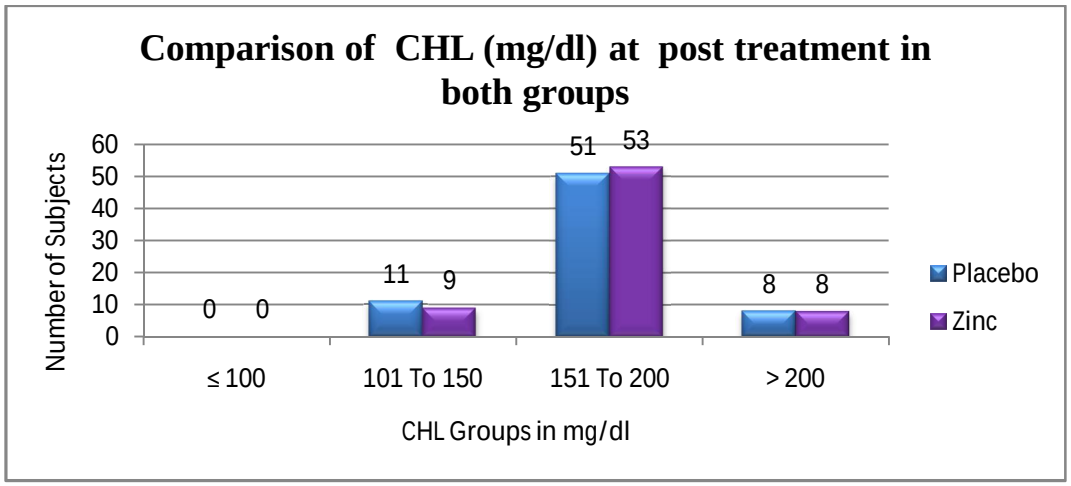


TABLE 5.41 COMPARISON OF CHL (MG/DL) AT POST TREATMENT IN BOTH GROUPS

CHL Post Treatment	Placebo	%	Zinc	%
≤ 100	0	0.00	0	0.00
101 To 150	11	15.71	9	12.86
151 To 200	51	72.86	53	75.71
> 200	8	11.43	8	11.43
Total	70	100	70	100

TABLE 5.42 COMPARISON OF MEAN CHL POST TREATMENT IN BOTH GROUPS

CHL Post Treatment	Placebo	Zinc
N	70	70
Mean	172.1614	185.0286
SD	24.83353	121.1053
P value Unpaired t test	0.386644	

The difference within the treatment groups (pre and Post intervention) and total cholesterol levels is considered to be not statistically significant since p > 0.05. There is no effect of Zinc supplementation in total cholesterol levels.

Figure 5.25 Comparison of VLDL pre treatment in both groups

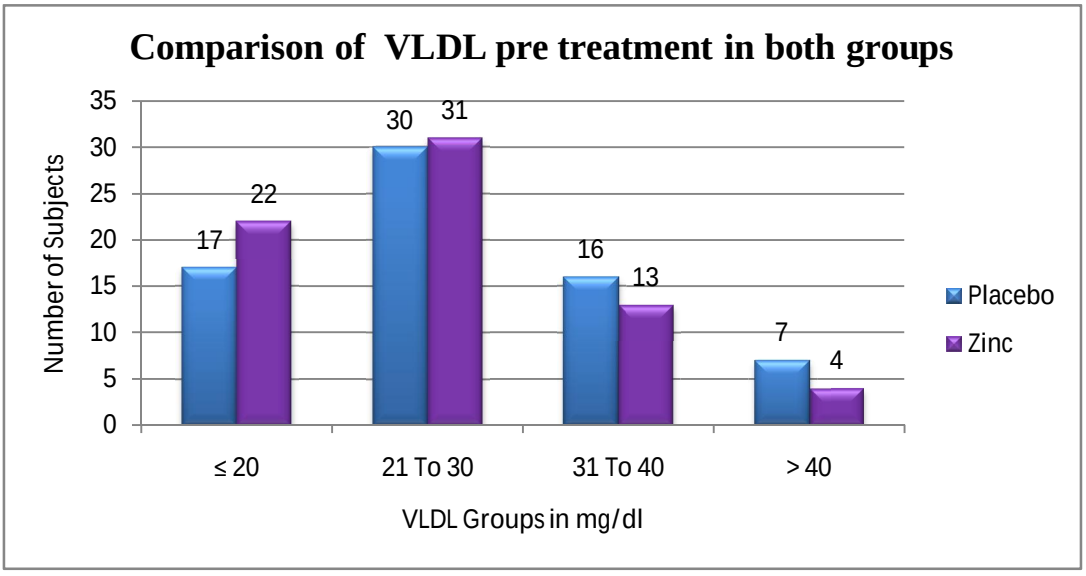


TABLE 5.43 COMPARISON OF VLDL PRE TREATMENT IN BOTH GROUPS

VLDL Pre Treatment	Placebo	%	Zinc	%
≤ 20	17	24.29	22	31.43
21 To 30	30	42.86	31	44.29
31 To 40	16	22.86	13	18.57
> 40	7	10.00	4	5.71
Total	70	100.00	70	100.00

TABLE 5.44 COMPARISON OF MEAN VLDL PRE TREATMENT IN BOTH GROUPS

VLDL Pre Treatment	Placebo	Zinc
N	70	70
Mean	28.02857	25.50571
SD	9.362354	8.199379
P value unpaired t test	0.206193	

Figure 5.26 Comparison of VLDL post treatment in both groups

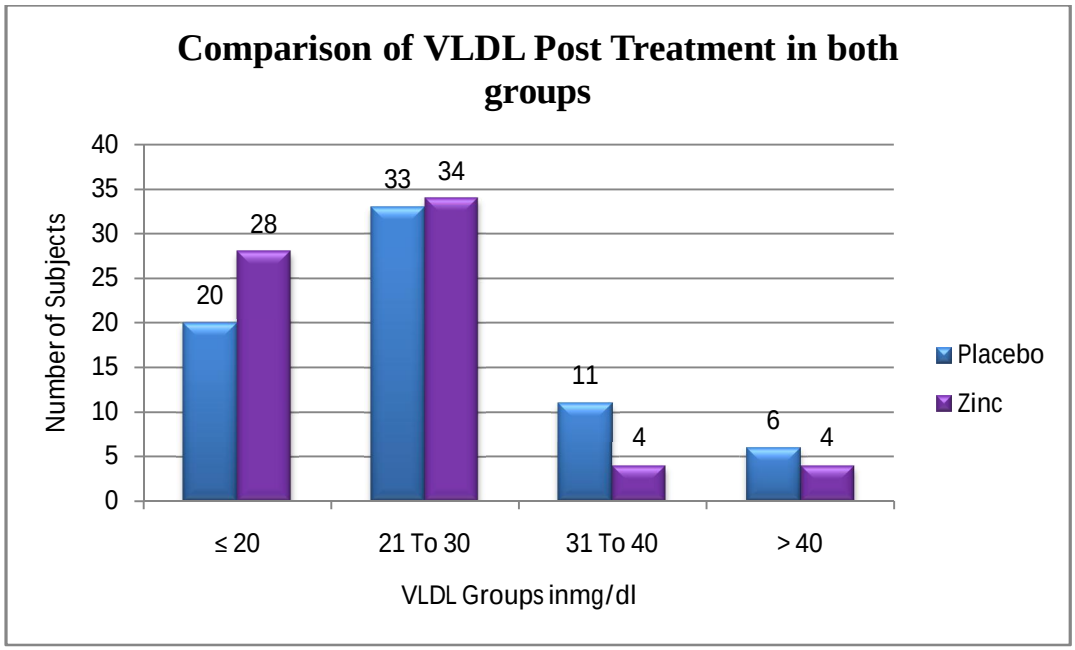


TABLE 5.45 COMPARISON OF VLDL POST TREATMENT IN BOTH GROUPS

VLDL Post Treatment	Placebo	%	Zinc	%
≤ 20	20	28.57	28	40.00
21 To 30	33	47.14	34	48.57
31 To 40	11	15.71	4	5.71
> 40	6	8.57	4	5.71
Total	70	100	70	100

TABLE 5.46 COMPARISON OF MEAN VLDL POST TREATMENT IN BOTH GROUPS

VLDL Post Treatment	Placebo	Zinc
N	70	70
Mean	25.50571	23.30571
SD	8.199379	7.489178
P value Unpaired t test	0.099704	

Mean VLDL for placebo group is 25.50571. Mean VLDL for Zinc group is 23.30571. The difference within the treatment groups (pre and Post intervention) and serum VLDL levels is considered to be not statistically significant since p > 0.05(0.0997).

TABLE 5.47 COMPARISON OF P VALUE FOR LIPID PROFILE

Lipid Profile	Post-Treatment		P value
	Placebo Mean±SD	Zinc Mean±SD	
LDL	95.64±16.75	109.37±27.36	0.50
TGL	109.03±32.36	112.15±30.44	0.55
HDL	50.35±7.16	53.81±7.21	0.51
CHL	172.16±24.83	185.03±21.11	0.38
VLDL	25.51±8.20	23.31±7.49	0.09

From the table, it is evident that there is no significant difference in the levels of LDL cholesterol, Triglycerides, HDL cholesterol, Total cholesterol and VLDL cholesterol between the two groups. Hence there is no significant change in lipid profile on Zinc supplementation to diabetic individuals.

Figure 5.27 Comparison of ESR at pre treatment in both groups

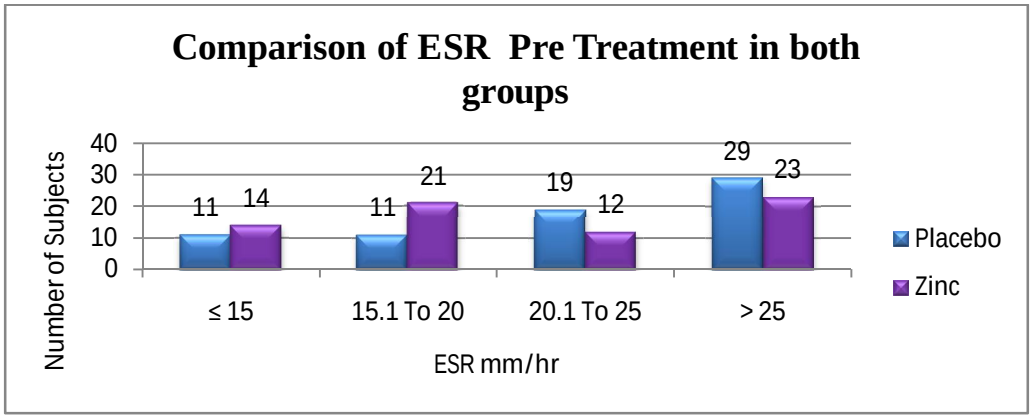


TABLE 5.48 COMPARISON OF ESR AT PRE TREATMENT IN BOTH GROUPS

ESR Pre Treatment	Placebo	%	Zinc	%
≤ 15	11	15.71	14	20.00
15.1 To 20	11	15.71	21	30.00
20.1 To 25	19	27.14	12	17.14
> 25	29	41.43	23	32.86
Total	70	100.00	70	100.00

TABLE 5.49 COMPARISON OF MEAN ESR PRE TREATMENT IN BOTH GROUPS

ESR Pre Treatment	Placebo	Zinc
N	70	70
Mean	25.98571	24.44286
SD	13.56305	13.13766
P value		
	0.062279	
Unpaired t test		

Figure 5.28 Comparison of ESR at post treatment in both groups

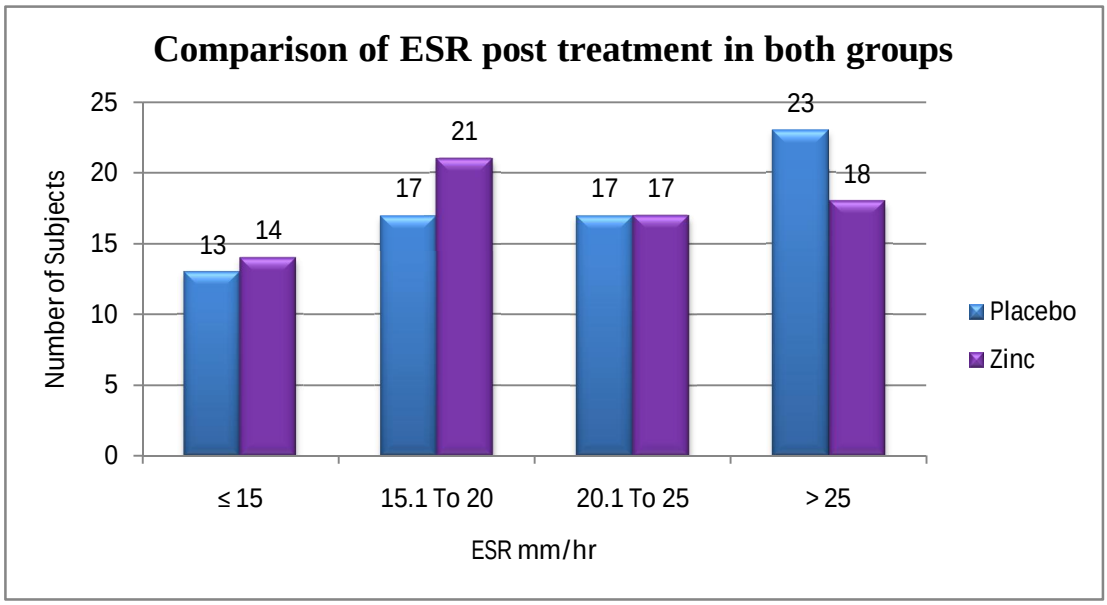


TABLE 5.50 COMPARISON OF ESR POST TREATMENT IN BOTH GROUPS

ESR Post Treatment	Placebo	%	Zinc	%
≤ 15	13	18.57	14	20.00
15.1 To 20	17	24.29	21	30.00
20.1 To 25	17	24.29	17	24.29
> 25	23	32.86	18	25.71
Total	70	100	70	100

TABLE 5.51 COMPARISON OF MEAN ESR POST TREATMENT IN BOTH GROUPS

ESR Post Treatment	**Placebo**	**Zinc**
N	70	70
Mean	24.44286	21.3
SD	13.13766	8.022342
P value Unpaired t test	0.090316	

The difference within the treatment groups (pre and Post intervention) and ESR levels is considered to be not statistically significant since p > 0.05(0.0903).

Figure 5.29 Comparison of Serum Zinc pretreatment in both groups

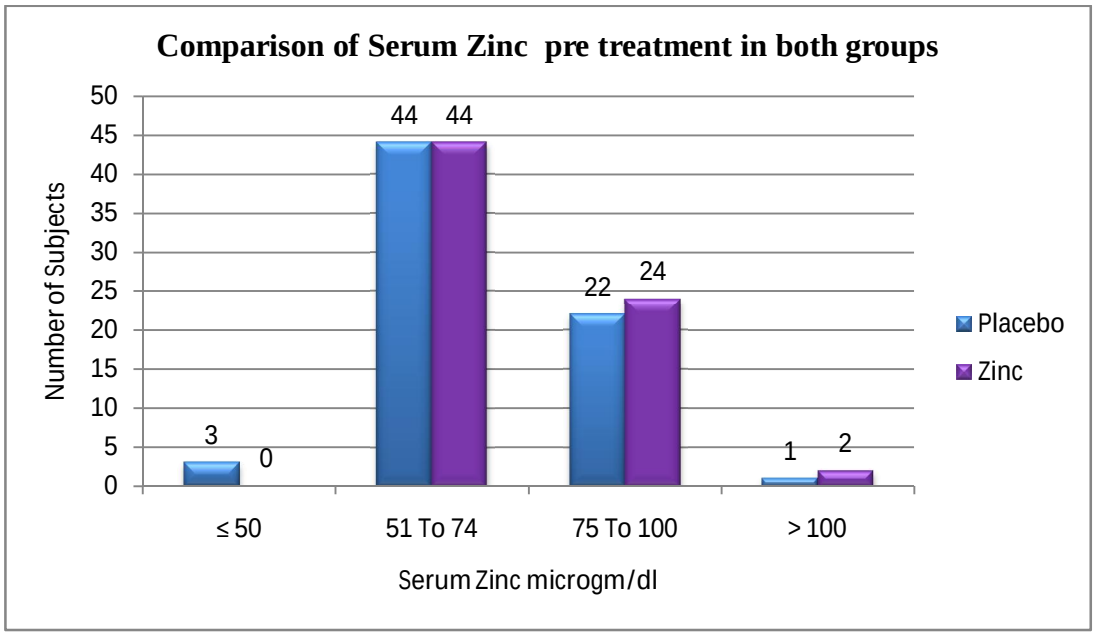


TABLE 5.52 COMPARISON OF SERUM ZINC (MICROGM/DL) PRETREATMENT IN BOTH GROUPS

S. ZINC Pre Treatment	Placebo	%	Zinc	%
≤ 50	3	4.29	0	0.00
51 To 74	44	62.86	44	62.86
75 To 100	22	31.43	24	34.29
> 100	1	1.43	2	2.86
Total	70	100.00	70	100.00

TABLE 5.53 COMPARISON OF MEAN SERUM ZINC PRE TREATMENT IN BOTH GROUPS

S. ZINC Pre Treatment	Placebo	Zinc
N	70	70
Mean	71.28571	70.9
SD	12.54458	11.16821
P value Unpaired t test	0.382129	

Figure 5.30 Comparison of Serum Zinc post treatment in both groups

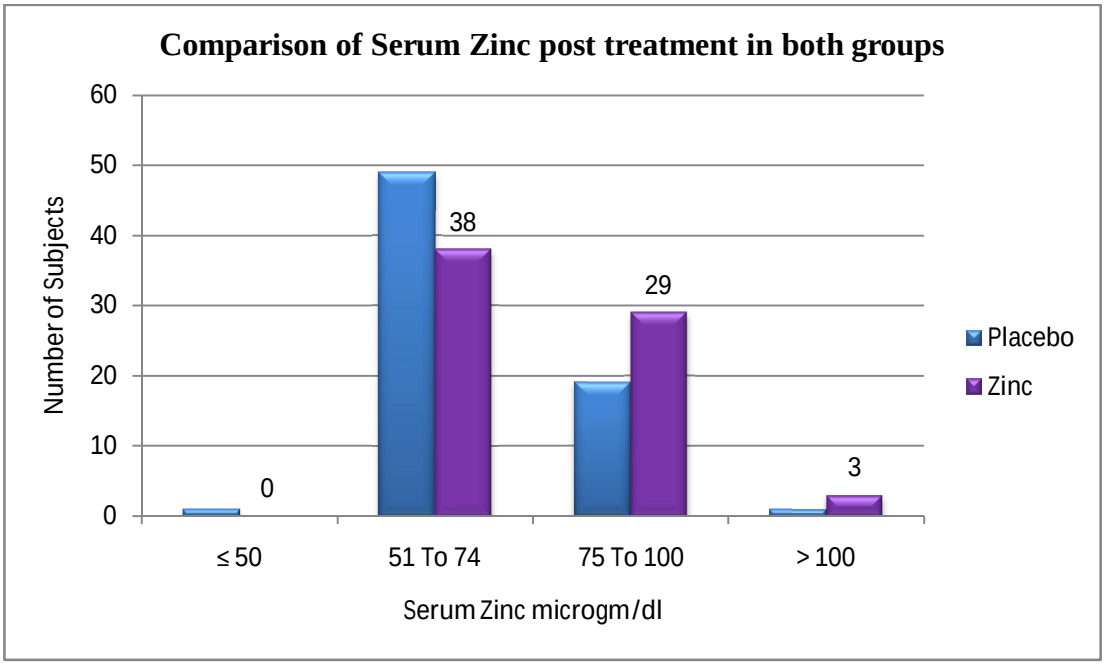


TABLE 5.54 COMPARISON OF SERUM ZINC POST TREATMENT IN BOTH GROUPS

S. ZINC Post Treatment	Placebo	%	Zinc	%
≤ 50	1	1.43	0	0.00
51 To 74	49	70.00	38	54.29
75 To 100	19	27.14	29	41.43
> 100	1	1.43	3	4.29
Total	70	100	70	100

TABLE 5.55 COMPARISON OF SERUM ZINC POST TREATMENT IN BOTH GROUPS

S. ZINC Post Treatment	Placebo	Zinc
N	70	70
Mean	70.9	76.11
SD	11.16821	11.32337
P value Unpaired t test	0.006896***	

*** Significant

Mean S.Zinc levels in post treatment placebo group is 70.9. Mean S.Zinc levels post treatment Zinc group is 76.11. p value for S.Zinc levels between the two groups is 0.00689 which is statistically significant.

DISCUSSION

Zinc deficiency has been shown to be associated with progression of diabetes and its supplementation has been shown to delay the progression from prediabetic to diabetic stage. It has also been shown to increase the insulin secretion. In vitro trials, have shown a strong association between DM & Zinc in insulin secreting β cells in pancreas and also by demonstrating their role in the pathogenesis of Type 1 & 2DM. Trials relating to intervention with Zinc to improve glycemic parameters and its outcome are small in number and their results are conflicting.

This is because, all the studies which were conducted had

1. Small population which cannot be generalized to public,
2. Duration of the study was very small,
3. Zinc doses for DM was not specified and not uniform in these studies,
4. Geographical factors which influence the study, as most of the trials were conducted in western world
5. Race –most of the studies were conducted in white population.

More studies are needed to estimate the exact prevalence of Zinc deficiency in both urban and rural India, which should be community based. This is because our country has a population distinct from other region of the world, by having patients with diabetes with lean body mass. Hence there is a need to evaluate Zinc's clinical utility in T2 DM which will be an effective , affordable, public health measure like iodine. Trials have shown that Zinc supplementation in patients with IGT increases insulin secretion and its sensitivity and some other trials have shown that there is no benefit of supplementing Zinc in patients with complications or those requiring insulin . Hence role of Zinc and its mechanism to improve the glycemic state of newly detected Type 2 Diabetic patients has to be undertaken, as this group of patients have about 50% of the beta cell mass which if appropriately protected may prevent or delay the complications.

In our study Mean age of the subjects was included with placebo group is 48.17 and Zinc group is 47.27. There is no significance between the groups implying that there is about equal distribution in the Groups. Lowest age in the study is 29 years and highest age 67 years. Maximum number of patients were between the 41-50 years. There was about equal distribution of the male and female patient about 1:1 ratio totally and in all groups. These results were correlated with WHO statistics.

Serum Zinc levels in most of the subjects in both groups were below 75 microgm/dl before Zinc supplementation. After Zinc supplementation Serum Zinc levels were significantly increased . Statiscally this indicates that there is a true difference within the Zinc supplementation group (pre and Post intervention) in relation to HBA1c levels and the difference is significant.

FBG :

In simple terms, with Zinc supplementation in newly detected type 2 diabetic patients, the fasting blood glucose levels is reduced by 22 mg/dl in comparison with placebo which reduces fasting blood sugar levels by 9.57 mg/dl with a p-value of 0.00079 according to unpaired t-test. This indicates that there is a true difference within the Zinc supplementation group (pre and Post intervention) in relation to fasting blood glucose levels and the difference is significant. The reduction in fasting blood glucose levels was meaningfully more (17%) in the Zinc supplementation group compared to the placebo group . This difference is true and significant and has not occurred by chance. We conclude that there is real advantage by addition of Zinc in newly detected type 2 diabetic patients, which in turn decreases the fasting blood glucose levels significantly. Similar study was conducted by Jayawaradhane et al

concluded that the pooled mean difference for FBG between Zinc supplemented and placebo groups from random effects analysis was −18.13 mg/dl.(95% CI:–33.85,–2.41; $p<0.05$).

Another study done by Priyanka Gunasekara et al concluded that Zinc and supplementation showed beneficial effects in the metabolic control of adult diabetics in addition to elevating their serum Zinc level.

PPBG :

In simple terms, with Zinc supplementation in newly detected type 2 diabetic patients, the post prandial blood glucose levels is reduced by 45 mg/dl in comparison with placebo which reduces post prandial blood sugar levels by 16 mg/dl with a p-value of 0.0323 according to unpaired t-test. The reduction in post prandial blood glucose levels was meaningfully more (61%) in the Zinc supplementation group compared to the placebo group. This indicates that there is a true difference within the Zinc supplementation group (pre and Post intervention) in relation to post prandial blood glucose levels and the difference is significant. This difference is true and significant and has not occurred by chance. We conclude that there is real advantage by addition of Zinc in newly detected type 2 diabetic patients, which in turn decreases the post prandial blood glucose levels significantly.

HBA1c :

Zinc supplementation in newly detected type 2 diabetic patients, the HBA1c levels is reduced by 0.95% in comparison with placebo which reduces HBA1c levels by 0.25% with a p-value of 0.00036 according to unpaired t-test. The reduction in HBA1c levels was meaningfully more (79%) in the Zinc supplementation group compared to the placebo group by 0.097 %. This difference is true and significant and has not occurred by chance. We conclude that there is real advantage by addition of Zinc in newly detected type 2 diabetic patients, which in turn decreases the HBA1c levels significantly.

Lipid profile :

The difference within the treatment groups (pre and Post intervention) and serum VLDL, TG, CHL, HDL, LDL levels is considered to be not statistically significant since $p > 0.05$.

BMI has not changed significantly after supplementation of Zinc ($p=0.186$). BMI in pre interventional and post interventional groups was 27.97 and 26.99 respectively. Jihye kim et al showed that BMI did not change after Zinc supplementation. This has been well correlating with our results.

ESR has also shown no significance after Zinc supplementation. Other parameters like renal function test, Hemogram have also shown no significant association after supplementation of Zinc. Trials which have been conducted earlier too did not show statistically significant improvement in lipid profile or other parameters.

LIMITATIONS OF THE STUDY

1. The sample size was too small to extrapolate it to general population.

2. The follow up period was short.

3. The efficacy of Zinc as monotherapy could not be evaluated due to ethical considerations.

4. Variations in baseline parameters such as serum Zinc status, blood glucose and lipid levels.

5. Differences in Zinc doses, formulae, sample sizes and study durations.

6. Limited availability of data on Zinc intake from other sources such as diet.

CONCLUSION

Zinc supplementation improves glycemic parameters HbA1C, FBG, PPBG in newly detected Type 2 Diabetics when compared to placebo group.Thus, it appears that the beneficial effects of Zinc supplementation on metabolic parameters can be seen mainly in individuals with Zinc deficiency or diseases causing Zinc deficiency such as diabetes.

In our study, which was done on newly detected Type 2 DM patients OHA and Zinc supplementation have shown better glycemic control than in placebo group with similar control of FBG & PPBG in Group 2 who received 50 mg/day. HbA1C also shows significant decrease in Group 2 compared to placebo Group after 6 months of supplementation with a p 0.00036 (<0.05). Zinc supplementation with oral hypoglycemic agents may provide better glycemic control. There is no significant effect on fasting lipid profile after Zinc supplementation.

BIBLIOGRAPHY

1. Papaspyros NS. The history of diabetes. In: Verlag GT, ed. The History of Diabetes Mellitus. Stuttgart: Thieme; 1964:4.

2. http://www.crystalinks.com/egyptmedicine.html – ancient Egyptian medicine, Ebers papyrus.

3. Papaspyros NS. The history of diabetes. In: Verlag GT, ed. The History of Diabetes Mellitus. Stuttgart: Thieme; 1964:4–5.

4. Medvei VC. The Greco – Roman period. In:Medvei VC, ed. The History of Clinical Endocrinology: A Comprehensive Account of Endocrinology from Earliest Times to the Present Day. New York: Parthenon Publishing; 1993:34, 37.

5. Southgate TM. De medicina. JAMA. 1999;10:921.

6. Medvei VC. The 16th century and the Renaissance. In: Medvei VC, ed. The History of Clinical Endocrinology: A Comprehensive Account of Endocrinology from Earliest Times to the Present Day. New York: Parthenon Publishing; 1993:55–56.

7. MacCracken J. From ants to analogues. Puzzles and promises in diabetes management. Postgrad Med. 1997;4:138–150.

8. Medvei VC. Present trends and outlook for the future – Part III. In: Medvei VC, ed. The History of Clinical Endocrinology: A Comprehensive Account of Endocrinology from Earliest Times to the Present Day. New York: Parthenon Publishing; 1993: 380–383

9. Medvei VC. Chronological tables. In: Medvei VC, ed. The History of Clinical Endocrinology: A Comprehensive Account of Endocrinology from Earliest Times to the Present Day. New York: Parthenon Publishing; 1993:495.

10. Galloway J, deShazo R. Insulin chemistry and pharmacology: insulin allergy, resistance, and lipodystrophy. In: Rifkin H, Porte D Jr, eds. Diabetes Mellitus. Theory and Practice. 4th ed. New York: Elsevier; 1990:498.

11. Williams textbook of endocrinology (12th ed.). Philadelphia: Elsevier/Saunders. pp. 1371–1435. ISBN 978-1-4377-0324-5.

12. Jump up^ "Simple treatment to curb diabetes". January 20, 2014.

13. Jump up to:[a] [b] [c] Wild S, Roglic G, Green A, Sicree R, King H (2004). "Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030". Diabetes Care 27 (5): 1047–53.doi:10.2337/diacare.27.5.1047. PMID 15111519

14. "China faces 'diabetes epidemic', research suggests". BBC. March 25, 2010. Retrieved 8 June 2012.

15. Jump up to:[a] [b] [c] Gale, Jason (November 7, 2010). "India’s Diabetes Epidemic Cuts Down Millions Who Escape Poverty". Bloomberg. Retrieved 8 June 2012.

16. Jump up^ "Diabetes can be controlled in 80 percent of Cases in India". IANS. news.biharprabha.com. Retrieved 6 February 2014.

17. Jump up^ Kleinfield, N. R. (September 13, 2006). "Modern Ways Open India's Doors to Diabetes". New York Times. Retrieved 8 June 2012.

18. Jump up Wild, Sarah, Gojka Roglic, Anders Green, Richard Sicree, and Hilary King. "Global Prevalence of Diabetes." Diabetes Care. American Diabetes Association, 26 Jan. 2004. Web. 22 Apr. 2014.

19. Simon SF, Taylor CG: **Dietary zinc supplementation attenuates hyperglycemia in db/db mice.** *Exp Biol Med (Maywood)* 2001, **226:**43-51

20. Faure P, Benhamou PY, Perard A, Halimi S, Roussel AM: **Lipid peroxidation in insulin-dependent diabetic patients with early retina degenerative lesions: Effects of an oral zinc supplementation.** *Eur J Clin Nutr* 1995, **49:**282-288. PubMed Abstract

21. Shidfar F, Aghasi M, Vafa M, Heydari I, Hosseini S, Shidfar S: **Effects of combination of zinc and vitamin A supplementation on serum fasting blood sugar, insulin, apoprotein B and apoprotein A-I in patients with type i diabetes.** *International Journal of Food Sciences and Nutrition* 2010, **61:**182-191. PubMed Abstract | Publisher Full Text

22. Afkhami-Ardekani M, Karimi M, Mohammadi SM, Nourani F: **Effect of zinc sulfate supplementation on lipid and glucose in type 2 diabetic patients.** *Pak J Nutr* 2008, **7:**550-553. Publisher Full Text

23. Al-Maroof RA, Al-Sharbatti SS: **Serum zinc levels in diabetic patients and effect of zinc supplementation on glycemic control of type 2 diabetics.** *Saudi Medical Journal* 2006, **27:**344-350. PubMed Abstract

24. Ioannidis JP: **Contradicted and initially stronger effects in highly cited clinical research.** *JAMA* 2005, **294:**218-228. PubMed Abstract | Publisher Full Text

25. de Sena KC, Arrais RF: **das Gracas Almeida M, de Araujo DM, dos Santos MM, de Lima VT, de Fatima Campos Pedrosa L: Effects of zinc supplementation in patients with type 1 diabetes.** *Biol Trace Elem Res* 2005, **105:**1-9. PubMed Abstract | Publisher Full Text

26. Freeman SR, Williams HC, Dellavalle RP: **The increasing importance of systematic reviews in clinical dermatology research and publication.** *J Invest Dermatol* 2006, **126:**2357-2360. PubMed Abstract | Publisher Full Text

27. Diabetes Care 1997;20:1183-1195

28. Shankar AH, Prasad AS. Zinc and immune function : the biological basis of altered resistance to infection. Am J Clin Nutrition 1998;68 :447s-63S

29. Hiroyuki YANAGISAWA. Zinc Deficiency and Clinical Practice JMAJ 47(8): 359–364, 2004

30. Institute of medicine, Food and Nutrition board. Dietary Reference Intakes for Zinc Washington, DC: National Academy press,2001

31. Medline plus-drug information-natural-982

32. Lewis MR, Kokan L. Zinc gluconate : acute ingestion. J Toxicology Clinical Toxicol 1998;36;99-101.[pubmed extract]

33. Hooper PL,Visconti L, Garry PJ, Johnson GE. Zinc lowers high density lipoprotein-cholesterol levels. J Am Med Association 1980;244:1960-61 [pubmed abstract]

34. Stumvoll M, Goldstein BJ, van Haeften TW: Type 2 diabetes: principles of pathogenesis and therapy. Lancet 2005, 365:1333–1346. 7. Dodson G, Steiner D: The role of assembly in insulin's biosynthesis. Curr Opin Struct Biol 1998, 8:189–194.

35. Noormagi A, Gavrilova J, Smirnova J, Tougu V, Palumaa P: Zn(II) ions cosecreted with insulin suppress inherent amyloidogenic properties of
monomeric insulin. Biochem J 2010, 430:511–518.

36. Zalewski P, Millard S, Forbes I, Kapaniris O, Slavotinek S, Betts W, Ward A, Lincoln S, Mahadevan I: Video image analysis of labile Zn in viable pancreatic islet cells using specific fluorescent probe for Zn. J Histochem Cytochem 1994, 42:877–884.

37. Arquilla ER, Packer S, Tarmas W, Miyamoto S: The effect of zinc on insulin metabolism. Endocrinology 1978, 103:1440–1449.

38. Chausmer AB: Zinc, insulin and diabetes. J Am Coll Nutr 1998, 17:109–115.

39. Kelly F: Use of antioxidants in the prevention and treatment of disease. J
Int Fed Clin Chem 1998, 10:21–23.

40. Garg VK, Gupta R, Goyal RK: Hypozincemia in diabetes mellitus. J Assoc Physicians India 1994, 42:720–721.

41. Pidduck HG, Wren PJ, Evans DA: Hyperzincuria of diabetes mellitus and
possible genetical implications of this observation. Diabetes 1970, 19:240–247.

42. Black RE: Zinc deficiency, infectious disease and mortality in the developing world. J Nutr 2003, 133:1485S–1489S.

43. Simon SF, Taylor CG: Dietary zinc supplementation attenuates hyperglycemia in db/db mice. Exp Biol Med (Maywood) 2001, 226:43–51.

44. Faure P, Benhamou PY, Perard A, Halimi S, Roussel AM: Lipid peroxidation in insulin-dependent diabetic patients with early retina degenerative lesions: Effects of an oral zinc supplementation. Eur J Clin Nutr 1995, 49:282–288.

45. Shidfar F, Aghasi M, Vafa M, Heydari I, Hosseini S, Shidfar S: Effects of

combination of zinc and vitamin A supplementation on serum fasting blood sugar, insulin, apoprotein B and apoprotein A-I in patients with type I diabetes. International Journal of Food Sciences and Nutrition 2010, 61:182–191.

46. Afkhami-Ardekani M, Karimi M, Mohammadi SM, Nourani F: Effect of zinc sulfate supplementation on lipid and glucose in type 2 diabetic patients. Pak J Nutr 2008, 7:550–553.

47. Al-Maroof RA, Al-Sharbatti SS: Serum zinc levels in diabetic patients and effect of zinc supplementation on glycemic control of type 2 diabetics. Saudi Medical Journal 2006, 27:344–350.

48. J. Jansen, E. Rosenkranz, S. Overbeck et al., “Disturbed Zinc homeostasis in diabetic patients by in vitro and in vivo analysis of insulinomimetic activity of Zinc,” The Journal of Nutritional Biochemistry, vol. 23, pp. 1458–1466, 2012.

49. D. Scott, “Crystalline insulin,” The Biochemical Journal, vol. 28, pp. 1592–1602, 1934.

50. P. J. Little, R. Bhattacharya, A. E. Moreyra, and I. L. Korichneva, “Zinc and cardiovascular disease,” Nutrition, vol. 26,no. 11-12, pp. 1050–1057, 2010.

51. S. L. Kelleher, N. H. McCormick, V. Velasquez, and V. Lopez, “Zinc in specialized secretory tissues: roles in the pancreas,prostate, and mammary gland,” Advances in Nutrition, vol. 2,pp. 101–111, 2011.

52. N. Stadler, S. Heeneman, S. Voo et al., “Reduced metal ion concentrations in atherosclerotic plaques from subjects with type 2 diabetes mellitus,” Atherosclerosis, vol. 222, pp. 512–518, 2012.

53. A. K. Jayaraman and S. Jayaraman, “Increased level of exogenous Zinc induces cytotoxicity and up-regulates the expression of the ZnT-1 Zinc transporter gene in pancreatic cancer cells,” The Journal of Nutritional Biochemistry, vol. 22, no. 1, pp. 79–88, 2011.

54. C. Hogstrand, P. Kille, R. I. Nicholson, and K. M. Taylor, “Zinc transporters and cancer: a potential role for ZIP7 as a hub for tyrosine kinase activation,” Trends in Molecular Medicine, vol. 15, no. 3, pp. 101–111, 2009.

55. A. J. Delli, F. Vaziri-Sani, B. Lindblad et al., “Zinc transporter 8 autoantibodies and their association with SLC30A8 and HLA-DQ genes differ between immigrant and Swedish patients with newly diagnosed type 1 diabetes in the better diabetes diagnosis study,” Diabetes, vol. 10, pp. 2556–2564, 2012.

56. E. Kawasaki, K. Nakamura, G. Kuriya et al., “Differences in the humoral autoreactivity to Zinc transporter 8 between childhood- and adult-onset type 1 diabetes in Japanese patients,” Clinical Immunology, vol. 138, no. 2, pp. 146–153, 2011.

57. N. Patrushev, B. Seidel-Rogol, and G. Salazar, “Angiotensin II requires Zinc and downregulation of the Zinc transporters ZnT3 and ZnT10 to induce senescence of vascular smooth muscle cells,” PLoS One, vol. 7, Article ID e33211, 2012.

58. G. Lyubartseva, J. L. Smith, W. R. Markesbery, and M. A. Lovell, “Alterations of Zinc transporter proteins ZnT-1, ZnT- 4 and ZnT-6 in preclinical Alzheimer’s disease brain,” Brain Pathology, vol. 20, no. 2, pp. 343–350, 2010.

59. C. Devirgiliis, P. D. Zalewski, G. Perozzi, and C. Murgia, “Zinc fluxes and Zinc transporter genes in chronic diseases,” Mutation Research, vol. 622, no. 1-2, pp. 84–93, 2007.

60. C. Chasapis, A. Loutsidou, C. Spiliopoulou, and M. Stefanidou, “Zinc and human health: an update,” Archives of Toxicology, vol. 86, pp. 1–14, 2011.

61. T. Fukada, S. Yamasaki, K. Nishida, M. Murakami, and T.Hirano, “Zinc homeostasis and signaling in health and diseases—Zinc signaling,” Journal of Biological Inorganic Chemistry, vol. 16, pp. 1123–1134, 2011.

62. C. Andreini, L. Banci, I. Bertini, and A. Rosato, “Counting the Zinc-proteins encoded in the human genome,” Journal of Proteome Research, vol. 5, no. 1, pp. 196–201, 2006.

63. E. Mocchegiani, R. Giacconi, and M. Malavolta, “Zinc signaling and subcellular distribution: emerging targets in type 2 diabetes,” Trends in Molecular Medicine, vol. 14, no. 10, pp. 419–428, 2008.

64. T. Kambe, “An overview of a wide range of functions of ZnT and Zip Zinc transporters in the secretory pathway,” Bioscience,

Biotechnology and Biochemistry, vol. 75, no. 6, pp. 1036–1043, 2011.

65. D. Beyersmann and H. Haase, “Functions of Zinc in signaling, proliferation and differentiation of mammalian cells,” BioMetals, vol. 14, no. 3-4, pp. 331–341, 2001.

66. M. Vaˇs´ak and D. W. Hasler, “Metallothioneins: new functional and structural insights,” Current Opinion in Chemical Biology, vol. 4, no. 2, pp. 177–183, 2000.

67. L. Coulston and P. Dandona, “Insulin-like effect of Zinc on adipocytes,” Diabetes, vol. 29, no. 8, pp. 665–667, 1980.

68. J. M. May and C. S. Contoreggi, “The mechanism of the insulin-like effects of ionic Zinc,” The Journal of Biological Chemistry, vol. 257, no. 8, pp. 4362–4368, 1982.

69. H. Haase and W. Maret, “Fluctuations of cellular, available Zinc modulate insulin signaling via inhibition of protein tyrosine phosphatases,” Journal of Trace Elements in Medicine and Biology, vol. 19, no. 1, pp. 37–42, 2005.

70. Y.-M.Ma, R.-Y. Tao, Q. Liu et al., “PTP1B inhibitor improves both insulin resistance and lipid abnormalities in vivo and in vitro,” Molecular and Cellular Biochemistry, vol. 357, pp. 65– 72, 2011.

71. R. Ilouz, O. Kaidanovich, D. Gurwitz, and H. Eldar-Finkelman, “Inhibition of glycogen synthase kinase-3β by bivalent Zinc ions: insight into the insulin-mimetic action of Zinc,” Biochemical and

Biophysical Research Communications, vol. 295, no. 1, pp. 102–106, 2002.

72. T. Moniz, M. J. Amorim, R. Ferreira et al., “Investigation of the insulin-like properties of Zinc(II) complexes of 3-hydroxy- 4-pyridinones: identification of a compound with glucose lowering effect in STZ-induced type I diabetic animals,” Journal of Inorganic Biochemistry, vol. 105, pp. 1675–1682, 2011.

73. S. F. Simon and C. G. Taylor, “Dietary Zinc supplementation attenuates hyperglycemia in db/db mice,” Proceedings of the Society for Experimental Biology andMedicine, vol. 226, no. 1, pp. 43–51, 2001.

74. N.Wijesekara, F. Chimienti, andM. B.Wheeler, “Zinc, a regulator of islet function and glucose homeostasis,” Diabetes, Obesity and Metabolism, vol. 11, no. 4, pp. 202–214, 2009.

75. Y. Yoshikawa, E. Ueda, Y. Kojima, and H. Sakurai, “The action mechanism of Zinc(II) complexes with insulinomimetic activity in rat adipocytes,” Life Sciences, vol. 75, no. 6, pp. 741–751, 2004.

76. N. R. Pandey, G. Vardatsikos, M. Z. Mehdi, and A. K. Srivastava, “Cell-type-specific roles of IGF-1R and EGFR in mediating Zn2+ -induced ERK1/2 and PKB phosphorylation,” Journal of Biological Inorganic Chemistry, vol. 15, no. 3, pp. 399–407, 2010.

77. I. Hwang, T. Yoon, C. Kim, B. Cho, S. Lee, and M. K. Song, “Different roles of Zinc plus arachidonic acid on insulin sensitivity between high fructose- and high fat-fed rats,” Life Sciences, vol. 88, no. 5-6, pp. 278–284, 2011

77. Reaven GM (1988) Role of Insulin Resistance in Human Disease. Diabetes 37:1595–1607.

78. Coulston L, Dandona P (1980) Insulin-like effect of zinc on adipocytes. Diabetes 29: 665–667.

79. Begin-Heick N, Dalpe-Scott M, Rowe J, Heick HM (1985) Zinc supplementation attenuates insulin secretory activity in pancreatic islets of the ob/ob mouse. Diabetes 34: 179–184.

80. Simon SF, Taylor CG (2001) Dietary zinc supplementation attenuates hyperglycemia in db/db mice. Exp Biol Med (Maywood) 226: 43–51.

81. Ynsa MD, Ren MQ, Rajendran R, Sidhapuriwala JN, van Kan JA, Bhatia M, Watt F. Zinc mapping and density imaging of rabbit pancreas endocrine tissue sections using nuclear microscopy. Microsc Microanal 2009. 15:345-352.

82. Chimienti F, Devergnas S, Favier A, Seve M. Identification and cloning of a beta-cell-specific zinc transporter, ZnT-8, localized into insulin secretory granules. Diabetes 2004. 53:2330-2337.

83. Gyulkhandanyan AV, Lu H, Lee SC, Bhattacharjee A, Wijesekara N, Fox JE, MacDonald PE, Chimienti F, Dai FF, Wheeler MB. Investigation of transport mechanisms and regulation of intracellular Zn2+ in pancreatic

84. Dunn MF. Zinc-ligand interactions modulate assembly and stability of the insulin hexamer - a review. BioMetals 2005. 18:295-303.

85. Faure P, Roussel AM, Martinie M, Osman M, Favier A, Halimi S. Insulin sensitivity in zinc-depleted rats: assessment with the euglycaemic hyperinsulinic clamp technique. Diabetes Metab 1991. 17:325-331.alpha-cells. J Biol Chem 2008. 283:10184-10197.

86. Chen MD, Liou SJ, Lin PY, Yang VC, Alexander PS, Lin WH. Effects of zinc supplementation on the plasma glucose level and insulin activity in genetically obese (ob/ob) mice. Biol Trace Elem Res 1998. 61:303-311.

87. Qian WJ, Aspinwall CA, Battiste MA, Kennedy RT. Detection of secretion from single pancreatic beta-cells using extracellular fluorogenic reactions and confocal fluorescence microscopy. Anal Chem 2000. 72:711-717.

88. Kambe T, Narita H, Yamaguchi-Iwai Y, Hirose J, Amano T, Sugiura N, Sasaki R, Mori K, Iwanaga T, Nagao M. Cloning and characterization of a novel mammalian zinc transporter, zinc transporter 5, abundantly expressed in pancreatic beta cells. J Biol Chem 2002. 277:19049-19055.

89. Rother KI, Harlan DM. Challenges facing islet transplantation for the treatment of type 1 diabetes mellitus. J Clin Invest 2004. 114:877-883.

90. Papas KK, Colton CK, Nelson RA, Rozak PR, Avgoustiniatos ES, Scott WE 3rd, Wildey GM, Pisania A, Weir GC, Hering BJ. Human islet oxygen consumption rate and DNA measurements

predict diabetes reversal in nude mice. Am J Transplant 2007. 7:707-713.

91. Takahashi H, Tran PO, LeRoy E, Harmon JS, Tanaka Y, Robertson RP. D-glyceraldehyde causes production of intracellular peroxide in pancreatic islets, oxidative stress, and defective beta cell function via non-mitochondrial pathways. J Biol Chem 2004. 279:37316-37323.

92. Li N, Brun T, Cnop M, Cunha DA, Eizirik DL, Maechler P. Transient oxidative stress damages mitochondrial machinery inducing persistent beta-cell dysfunction. J Biol Chem 2009. 284:23602-23612.

93. Wang H, Kouri G, Wollheim CB. ER stress and SREBP-1 activation are implicated in beta-cell glucolipotoxicity. J Cell Sci 2005. 118:3905-3915.

94. Lupi R, Del Guerra S, Mancarella R, Novelli M, Valgimigli L, Pedulli GF, Paolini M, Soleti A, Filipponi F, Mosca F, Boggi U, Del Prato S, Masiello P, Marchetti P. Insulin secretion defects of human type 2 diabetic islets are corrected in vitro by a new reactive oxygen species scavenger. Diabetes Metab 2007. 33:340-345.

95. Evans JL, Goldfine ID, Maddux BA, Grodsky GM. Are oxidative stress-activated signaling pathways mediators of insulin resistance and beta-cell dysfunction? Diabetes 2003. 52:1-8.

96. Tang C, Han P, Oprescu AI, Lee SC, Gyulkhandanyan AV, Chan GN, Wheeler MB, Giacca A. Evidence for a role of superoxide

generation in glucose-induced betacell dysfunction in vivo. Diabetes 2007. 56:2722-2731.

97. Mohseni Salehi Monfared SS, Larijani B, Abdollahi M. Islet transplantation and antioxidant management: a comprehensive review. World J Gastroenterol 2009. 15:1153-1161.

98. Fontaine MJ, Fan W. Islet cell transplantation as a cure for insulin dependent diabetes: current improvements in preserving islet cell mass and function. Hepatobiliary Pancreat Dis Int 2003. 2:170-179.

99. Robertson RP. Oxidative stress and impaired insulin secretion in type 2 diabetes. Curr Opin Pharmacol 2006. 6:615- 619.

100. Lenzen S, Drinkgern J, Tiedge M. Low antioxidant enzyme gene expression in pancreatic islets compared with various other mouse tissues. Free Radic Biol Med 1996.20:463-466.

101. Blostein-Fujii A, DiSilvestro R, Frid D, Katz C, Malarkey W. Short-term zinc supplementation in women with non-insulin-dependent diabetes mellitus: effects on plasma 5'-nucleotidase activities, insulin-like growth factor I concentrations, and lipoprotein oxidation rates in vitro. Am J Clin Nutr 1997. 66:639-642.

102. Zago MP, Oteiza PI. The antioxidant properties of zinc: interactions with iron and antioxidants. Free Radic Biol Med 2001. 31:266-274.

103. Bolkent S, Yanardag R, Mutlu O. The influence of zinc supplementation on the pancreas of streptozotocin-diabetic rats. Dig Dis Sci 2009. 54(12):2583-2587.

104. Yoshikawa Y, Ueda E, Kojima Y, Sakurai H. The action mechanism of zinc(II) complexes with insulinomimetic activity in rat adipocytes. Life Sci 2004. 75:741-751.

105. Coudray C, Richard MJ, Laporte F, Faure P, Roussel AM, Favier A. Superoxide dismutase activity and zinc status: a study in animals and man. J Nutr Environ Med 1992.3:13-26.

106. Parham M, Amini M, Aminorroaya A, Heidarian E. Effect of zinc supplementation on microalbuminuria in patients with type 2 diabetes: a double blind, randomized, placebo- controlled, cross-over trial. Rev Diabet Stud 2008. 5(2):102-109.

107. You ZL, Shi DH, Zhu HL. The inhibition of xanthine oxidase by the schiff base zinc (II) complex. Inorg Chem Commun 2006. 9:642-644.

108. Roussel AM, Kerkeni A, Zouari N, Mahjoub S, Matheau JM, Anderson RA. Antioxidant effects of zinc supplementation in Tunisians with type 2 diabetes mellitus. J Am Coll Nutr 2003. 22:316-321.

109. Ryan MJ, Jackson JR, Hao Y, Leonard SS, Alway SE. Inhibition of xanthine oxidase reduces oxidative stress and improves skeletal muscle function in response to electrically stimulated isometric contractions in aged mice. Free Radic Biol Med 2010. In press.

110. Ohly P, Dohle C, Abel J, Seissler J, Gleichmann H. Zinc sulphate induces metallothionein in pancreatic islets of mice and protects against diabetes induced by multiple low doses of streptozotocin. Diabetologia 2000. 43:1020-1030.

111. Chang KL, Hung TC, Hsieh BS, Chen YH, Chen TF, Cheng HL. Zinc at pharmacologic concentrations affects cytokine expression and induces apoptosis of human peripheral blood mononuclear cells. Nutrition 2006. 22(5):465-474.

112. Bao B, Prasad AS, Beck FW, Godmere M. Zinc modulates mRNA levels of cytokines. Am J Physiol Endocrinol Metab 2003. 285:E1095-E1102.

113. Cooper JT, Stroka DM, Brostjan C, Palmetshofer A, Bach FH, Ferran C. A20 blocks endothelial cell activation through a NF-kappaB-dependent mechanism. J Biol Chem 1996. 271:18068-18073.

Reg. No. _____

PROFORMA

1. NAME :
2. AGE / SEX :
3. ADDRESS :
4. COMPLAINTS :
5. PAST HISTORY :
6. PERSONAL HISTORY : SMOKING ALCOHOL
   SLEEP BOWEL & BLADDER HABITS
7. FAMILY HISTORY :
8. DRUG HISTORY :
9. GENERAL PHYSICAL EXAMINATION:
10. VITALS :

PR		**1**	**2**	**3**	**4**
BP					
HT					
WT					
BMI					
WHR					

11. S/E : CVS :
    RS :
    P/A :
    CNS

12. OPHTHALMIC EXAMINATION :

13. INVESTIGATION :

A) CBC

B) FBS

PPBS

C) HbA1C

F) ESR

G) hs CRP

H) RFT

I) MICROALBUMINURIA

J) ECG

K) ECHO

14. TREATMENT:

Date					

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PRE INTERVENTION GROUP

SL. NO	IP NO	GROUP	AGE (YEARS)	SEX	PRE-BMI	PRE-FBG mg/dl	PRE-PPBG mg/dl	PRE-HBA1c %	PRE-Urea mg/dl	PRE-Creat mg/dl	PRE-LDL mg/dl	PRE-TG mg/dl	PRE-HDL mg/dl	PRE-CHL mg/dl	PRE-VLDL mg/dl	PRE-Hb %	PRE WBC/ Cu mm	PRE-PLT cells/ cumm	PRE-ESR mm/hr	PRE-Urine glucose	PRE-U micro albumin mg/l	S.ZINC micro g/dl
1	15802407	1	45	F	27.53	140	220	7.6	18	0.8	56.8	85.7	49.1	123	17	10.20 %	6400	241000	21	0	3.22	56
2	13262803	1	39	F	21.06	166	259	6.9	27	0.3	59	83	38	190	23	11.6	7000	293000	45	0	6.8	60
3	21169635	1	50	M	28.53	154	271	7.8	39	0.5	139	130	49	203	34	12	4500	270000	45	1	7.6	65
4	15418904	1	38	F	27.23	160	287	6.9	40	0.56	88	97	48	240	24	9	4600	214000	34	0	6.23	69
5	15460918	1	29	M	26.6	180	300	8.5	18	0.65	129	110	49	228	24	14	5000	250000	39	0	7.6	70
6	1953258	1	49	F	30.8	176	323	6.7	49	0.68	90	98	62	204	36	13	4600	232000	35	1	6.7	89
7	17220654	1	46	F	29.06	154	254	6.8	30	0.67	120	98	46	254	48	12	6100	256000	34	1	1.45	90
8	13694195	1	47	M	32.04	197	264	7.2	28	0.45	109	87	49	287	34	10	5600	314000	21	0	6.5	45
9	15671377	1	56	F	23.53	152	275	7.8	32	0.62	98	119	41	187	29	12	4900	303000	23	0	8.6	50
10	11886089	1	58	M	33.53	173	286	6.9	33	0.56	107	97	60	164	26	11	5600	234000	32	0	1.4	70
11	15246133	1	65	F	33.98	183	265	6.5	39	0.44	111	86	48	184	56	13	5400	214000	24	1	7.8	65
12	17770034	1	35	M	26.68	179	275	6.8	34	0.56	129	98	52	194	45	10	6000	360000	22	1	2.24	49
13	21137046	1	56	F	28.88	129	285	7.3	35	0.67	149	134	45	190	39	9	4600	298000	9	0	7.8	56
14	12846025	1	67	F	29.41	153	298	8.5	17	0.44	139	129	39	168	40	13	9000	360000	23	1	5.6	78
15	14644613	1	57	M	27.08	189	198	7.5	19	0.35	138	278	40	183	35	11	6200	240000	28	0	1.48	77
16	12233560	1	58	F	23.13	192	204	9.1	23	0.43	140	249	35	187	31	9.8	5900	250000	16	2	5.67	65
17	13890074	1	54	M	28.15	175	208	8.7	29	0.74	130	143	31	180	29	9.3	5600	290000	29	1	8.6	64
18	11935914	1	60	F	29.41	196	280	8.1	30	0.79	89	160	48	190	33	10.5	11000	234000	98	0	5.64	109
19	12817186	1	54	F	27.41	163	276	8.3	33	0.39	96	96	38	198	45	10.4	6200	240000	11	1	5.6	98
20	21668962	1	48	M	31.95	183	289	8.4	32	0.75	90	98	59	178	49	11	5900	320000	31	0	8.6	90
21	20026778	1	54	F	23.33	180	298	8.5	33	0.77	97	93	45	193	19	9	8900	350000	19	1	5.9	76
22	21668926	1	44	F	26.6	140	222	7.5	18	0.8	56.8	85.7	49.1	123	17	10.2	6400	241000	21	1	3.22	69
23	20026877	1	38	M	30.08	129	258	6.9	14.6	0.55	139.6	83.4	38.2	173.52	17	11	7600	294000	49	0	6.88	72
24	12597961	1	38	M	29.06	138	345	7.8	27	0.58	88	130	48	160	21	11.3	5500	250000	34	0	7.88	75
25	20393376	1	50	F	32.46	134	196	7.08	28	0.76	129.6	97.3	46.3	157	23	10.9	6900	234000	28	0	4.67	65
26	21628703	1	44	M	23.53	178	320	8.5	30	0.9	90	110	44	180	20	10.8	8000	300000	45	2	8.98	67
27	17151241	1	47	F	33.98	131	195	7.15	28	0.62	129	96	62	224	19	13.2	9000	318000	10	0	11.16	65
28	16644988	1	40	M	26.85	145	212	7.2	21.1	0.56	121	87	46	187	18	14.8	5700	309000	29	1	6.98	64

29	117211049	1	49	M	28.88	140	187	7.4	19	0.43	127	136	49	208	27	10.8	7200	253000	21	0	7.66	79
30	13266624	1	47	F	29.41	134	230	6.9	24	0.56	124	146	41.6	214	17.6	13.2	8100	314000	30	1	6.82	56
31	17211049	1	29	M	27.08	176	248	7.8	34	0.51	120	85.2	60	204	17	11.7	10500	331000	22	0	5.6	79
32	13664566	1	46	F	23.18	156	246	7.3	28	0.42	76	84	48	164	28	14.3	7200	214000	34	1	9.46	86
33	17211049	1	47	M	31.95	140	240	7.8	40	0.67	78	86	52	184	25	13	4400	303000	6	0	6.7	76
34	13226656	1	56	F	23.66	130	210	7.1	24	0.48	104	98	45	194	30	14.3	6800	310000	20	0	7.8	64
35	17211049	1	43	M	26.83	134	188	6.98	21	0.71	98	134	39	194	26	14.2	8000	288000	22	0	8.66	60
36	14499464	1	57	F	28.04	194	315	9.1	25	0.61	95	278	40	190	56	12.3	12300	300000	18	0	6.5	59
37	14431445	1	52	M	28.88	160	280	7.8	16	0.76	80	101	35	168	27	13.1	8000	273000	28	0	1.48	54
38	20718112	1	53	F	27.58	132	167	6.8	13	0.67	125	135	31	183	27	14	10400	399000	9	0	2.24	67
39	16798901	1	45	F	29.47	160	292	7.4	33	0.8	100	130	48.5	180	25	10.4	9800	312000	16	2	13.8	60
40	16075225	1	52	F	23.11	159	208	7.71	11.1	0.79	78	105	38.3	170	33	14.3	6900	219000	11	1	3.56	99
41	21639157	1	48	M	27.39	158	225	7.12	34	0.69	89	176	59.4	189	25	11.7	5000	275000	31	0	5.67	77
42	20855170	1	50	F	26.48	166	248	7.41	19	0.68	96	88	45	156	17	11.1	7800	283000	19	0	8.64	75
43	16798901	1	35	M	24.99	126	210	7.1	14	0.5	70	76	48	140	12	11	6800	310000	12	1	6.8	72
44	16015225	1	50	M	28.25	155	335	7.9	18.6	0.77	156	123	51.4	232	24.6	15.3	7500	240000	19	0	7.47	65
45	21639157	1	41	M	31.16	126	186	7.1	23.9	0.75	102	176	48	210	35	11.8	6900	345000	14	0	7.8	69
46	20855170	1	48	F	27.04	147	240	7.6	20.7	0.7	115	115	44	232	33	11.4	6700	378000	13	0	8.99	59
47	1459800	1	38	M	23.61	162	320	8.2	28	0.45	80	120	52	230	32	13	6500	236000	24	1	6.7	88
48	12831804	1	44	M	24.38	210	314	9.2	32	0.48	82	122	54	180	28	12.3	9700	345000	22	1	8.4	87
49	14595800	1	58	F	26.83	132	274	7.1	18	0.62	113	68	34	140	22	10.8	4800	332000	17	1	4.2	83
50	12838104	1	39	F	27.43	210	234	7.8	32	0.54	142	152	54	228	32	11.4	9100	310000	25	2	4.4	86
51	21665478	1	44	M	28.9	146	294	7.6	28	0.48	122	103	38	134	24	8.3	4900	322000	20	1	3.28	82
52	14385636	1	56	M	23.22	162	243	8	26	0.61	64	104	48	206	26	9.4	4800	302000	21	0	4.67	86
53	21283778	1	48	F	30.08	128	216	7.1	18	0.54	94	108	48	168	19	9.6	7400	318000	32	0	4.21	75
54	16648686	1	47	M	29.06	146	264	7.6	28	0.7	76	88	44	170	18	12.8	7600	210000	45	0	5.6	65
55	21309276	1	48	F	32.46	130	210	7.6	36	0.64	130	117	42	198	31	12.2	7400	314000	24	1	12.6	58
56	20522554	1	63	F	23.53	148	230	7.45	24	0.6	110	100	48	180	26	13.1	7600	378000	18	0	8.88	69
57	16317857	1	29	F	33.98	140	222	7.5	18	0.84	56.8	85.7	49.1	123	18	10.2	6400	391000	21	1	3.22	70
58	20522554	1	46	M	26.85	129	258	6.9	14.6	0.74	139.6	83.4	38.2	173.52	20	11	7600	230000	49	0	6.88	60
59	16317857	1	47	F	28.88	138	345	7.8	27	0.78	88	130	48	160	19	11.3	5500	139000	34	1	7.88	64
60	17642561	1	53	M	29.41	134	196	7.08	28	0.75	129.6	97.3	46.3	157	23	10.9	6900	200000	28	0	4.67	72
61	20758111	1	43	F	27.08	178	320	8.5	30	0.8	90	110	44	180	28	10.8	8000	314000	45	1	8.98	61

62	20319047	1	57	M	23.18	131	195	7.15	28	0.64	129	96	62	224	25	13.2	9000	214000	10	0	11.16	70
63	20522541	1	52	F	31.95	145	212	7.2	21.1	0.64	121	87	46	187	37	14.8	5700	321000	29	0	6.98	69
64	21787011	1	53	M	23.66	140	187	7.4	19	0.44	127	136	49	208	26.8	10.8	7200	222000	21	0	7.66	64
65	20640387	1	45	F	26.83	134	230	6.9	24	0.83	124	146	41.6	214	35	13.2	8100	290000	30	0	6.82	88
66	22008912	1	56	M	28.04	176	248	7.8	34	0.5	120	85.2	60	204	29	11.7	10500	301000	22	0	5.6	79
67	20640387	1	38	F	24.38	156	246	7.3	28	0.5	76	84	48	164	41	14.3	7200	333000	34	1	9.46	72
68	21787011	1	45	M	26.83	140	240	7.8	40	0.65	78	86	52	184	18	13	4400	312000	6	0	6.7	63
69	20640387	1	58	F	27.43	130	210	7.1	24	0.86	104	98	45	194	25	14.3	6800	340000	20	1	7.8	64
70	22008912	1	51	M	28.9	134	188	6.98	21	0.56	98	134	39	194	23	14.2	8000	300000	22	0	8.66	91
71	21767662	2	44	M	29.06	194	315	9.1	25	0.76	95	278	40	190	38	12.3	12300	244010	18	0	6.5	82
72	17130038	2	38	M	27.23	160	280	7.8	16	0.79	80	101	35	168	36	13.1	8000	480000	28	0	1.48	74
73	11189548	2	38	F	27.41	132	167	6.8	13	0.48	125	135	31	183	34	14	10400	218000	9	0	2.24	81
74	21137719	2	50	F	27.58	160	292	7.4	33	0.93	100	130	48.5	180	22	10.4	9800	262000	16	1	13.8	64
75	15583252	2	44	M	28.08	159	208	7.71	11.1	0.68	78	105	38.3	170	19	14.3	6900	311000	11	0	3.56	63
76	11989862	2	47	F	26.42	158	225	7.12	34	0.73	89	176	59.4	189	11	11.7	5000	164000	31	0	5.67	66
77	17124908	2	40	M	40.95	166	248	7.41	19	0.49	96	88	45	156	34	11.1	7800	230000	19	0	8.64	61
78	21859096	2	49	F	26.83	126	210	7.1	14	0.48	70	76	48	140	31	11	6800	191000	12	1	6.8	62
79	21895069	2	47	F	33.33	155	335	7.9	18.6	0.68	156	123	51.4	232	65	15.3	7500	373000	19	0	7.47	59
80	12739185	2	29	F	20.19	126	186	7.1	23.9	0.62	102	176	48	210	19	11.8	6900	318000	14	0	7.8	60
81	11346370	2	46	M	35.65	147	240	7.6	20.7	0.65	115	115	44	232	48	11.4	6700	256000	13	0	8.99	59
82	16648686	2	47	M	25.96	162	320	8.2	28	0.43	80	120	52	230	16	13	6500	216000	24	1	6.7	61
83	16888211	2	53	F	25.68	210	314	9.2	32	0.71	82	122	54	180	30	12.3	9700	280000	22	1	8.4	71
84	16595726	2	43	F	28.34	132	274	7.1	18	0.46	113	68	34	140	32	10.8	4800	269000	17	1	4.2	61
85	21249528	2	57	F	31.64	210	234	7.8	32	0.6	142	152	54	228	34	11.4	9100	282000	25	1	4.4	62
86	17037224	2	52	M	25.77	140	294	7.6	28	0.62	122	103	38	134	56.2	8.3	4900	211000	20	1	3.28	66
87	17230819	2	53	F	23.45	129	243	8	26	0.75	64	104	48	206	20	9.4	4800	220000	21	0	4.67	62
88	21822062	2	45	M	26.39	138	216	7.1	18	0.8	94	108	48	168	25	9.6	7400	275000	32	0	4.21	67
89	13894911	2	52	M	26.12	134	264	7.6	28	0.92	76	88	44	170	25	12.8	7600	328000	45	0	5.6	62
90	21574188	2	48	M	26.25	178	210	7.6	36	0.8	130	117	42	198	22	12.2	7400	202000	24	1	12.6	72
91	13502105	2	50	M	27.39	131	230	7.45	24	0.68	110	100	48	180	22	13.1	7600	310000	18	0	8.88	71
92	15751154	2	35	M	28.3	145	251	7.81	22.1	0.75	110	91	46	180	17	14.3	7600	323000	40	1	4.55	61
93	14525119	2	50	F	26.92	140	299	7.5	31	0.8	118	89	41	170	17	10.3	6400	210000	34	0	6.89	59
94	14398572	2	41	F	27.71	134	497	8.91	23	0.64	104.5	110	48	171	21	11.3	7800	156000	45	0	11.4	60

95	15759898	2	48	M	26.67	176	211	7.01	15.5	0.64	121	110	47	200	23	12.9	5600	240000	32	0	5.88	61
96	1277314	2	38	F	36.65	156	287	8.1	37	0.44	134	98	45	210	20	9.8	8000	267000	37	2	13.7	62
97	22216735	2	44	M	26.39	140	240	7.2	30	0.9	136	98	56	181	19	14.1	5900	256000	28	0	8.8	66
98	16809812	2	58	F	26.02	130	395	8.9	18	0.5	83	90	48	211	18	12.7	7000	298000	16	1	14.98	62
99	23045720	2	39	F	25.6	134	390	7.7	23	0.8	139	126	47	220	27	11.9	6800	254000	19	0	11.52	61
100	11719288	2	44	F	24.73	194	225	8.1	30	0.55	126	140	43	210	17.6	11.8	7800	234000	40	0	7.89	69
101	152262803	2	56	M	28.04	160	189	7.3	23	0.58	114	90	58	174	17	15.1	8200	320000	30	0	8.6	70
102	152262803	2	48	F	31.2	132	230	6.9	25.11	0.6	131	88	50	182	28	11.5	8100	280000	10	0	12.67	77
103	15893981	2	47	F	28.95	160	217	7.1	28.9	0.8	117	83	49	203	25	13.5	5600	264000	18	0	6.7	98
104	22346647	2	48	M	23.83	159	195	7.6	40	0.61	107	90	46	188	30	14.9	5800	258000	26	0	18.99	72
105	15618182	2	63	F	19.84	158	276	8.9	36	0.54	88	130	38	190	26	12.4	7300	278000	16	0	8.48	81
106	22760164	2	44	M	23.55	166	260	8.01	32	0.7	70	150	41	176	56	9.6	9000	239000	23	0	8.01	71
107	16268641	2	52	F	23.66	126	210	7.4	12	0.64	108	93	37	188	27	10	7100	376000	38	0	8.04	65
108	12836218	2	64	M	24.12	155	238	8.4	18	0.6	104	110	35	181	27	14	8000	265000	19	0	8.4	69
109	20659906	2	52	F	32	126	215	6.8	15	0.9	79	98	45	176	25	11.4	4800	253000	21	2	7.8	71
110	20287401	2	62	M	30.46	147	182	6.7	9.8	0.5	119	87	41	180	33	15	6400	310000	17	0	6.8	72
111	20050082	2	45	F	26.57	162	300	8.4	25.8	0.8	79	154	59	174	25	12.3	6100	159000	26	0	3.2	77
112	17019822	2	64	M	26.66	210	205	7.32	15.6	0.55	115	90	46	156	17	9.4	6700	237000	26	0	16.8	78
113	11748724	2	29	F	17.96	132	373	9.3	28	0.58	120	87	48	221	12	8.4	6100	186000	16	1	11.8	72
114	21548941	2	65	M	27.04	210	211	7.9	31	0.76	66	99	50	198	24.6	11	6500	345000	10	0	8.4	69
115	13491258	2	48	F	31.64	146	328	8.7	29.5	0.9	112	145	49	210	35	13.5	7400	310000	22	0	2	101
116	14754383	2	50	M	27.68	162	187	6.9	30	0.62	68.4	110	45	220	33	9.2	8500	284000	9	0	8	95
117	20039204	2	60	F	27.23	128	300	12.57	18	0.56	139	105	52	172	32	11.2	7400	247000	42	1	8.2	82
118	21137361	2	66	M	28.06	146	215	6.5	20	0.43	98	115	54	150	28	11.4	5400	238000	30	1	8.48	72
119	22123711	2	38	F	23.87	130	373	10.61	13.7	0.56	118	78	35	190	22	12.2	5600	274000	28	1	6.89	69
120	15695276	2	45	F	28.06	148	292	7.7	21.3	0.51	178	134	55	150	32	15.7	8100	239000	18	2	18.16	71
121	21425927	2	48	M	27.37	142	259	6.6	21.9	0.42	137	110	38	198	24	12.2	5400	243000	23	1	9.85	72
122	17741710	2	50	F	25.63	153	238	7	14.5	0.67	116	110	47	178	26	15.6	7800	222000	10	1	6.91	77
123	2538017	2	65	M	29.77	246	240	7.3	28	0.48	110	95	49	165	19	10.76	7100	244000	20	0	3.66	86
124	20117052	2	46	M	24.65	131	343	8.6	22	0.71	98	94	45	189	18	12	7200	277000	29	0	2.8	88
125	21950232	2	44	F	25.91	145	254	7	14	0.61	62	105	41	168	31	11.2	6700	206000	18	2	5.18	90
126	17037422	2	36	F	27.4	130	266	7.1	30	0.76	88	96	48	188	26	13	5900	208000	24	0	7.89	101
127	17230198	2	29	M	21.08	262	320	7.2	14	0.67	121	140	44	210	18	11.2	9400	310000	22	1	5.45	98
128	21822620	2	38	F	21.96	219	302	8.4	18.6	0.8	98	100	52	184	21	12.2	6700	283000	34	0	7.89	87

129	13894918	2	50	F	26.4	127	260	7.4	23.9	0.79	110	94	54	188.8	20	12	8900	243000	6	0	10.87	82
130	21541788	2	39	M	26.56	132	328	7.8	20.7	0.69	134	115	34	178	22	10.2	6600	341000	20	0	6.78	81
131	13984912	2	60	M	26.72	142	336	7.98	28	0.68	154	90	54	168	21	11.4	7800	210000	22	2	12.4	82
132	21578144	2	52	F	19.13	117	300	8.01	32	0.5	164	86	38	161	17	15.8	8200	247000	18	0	9.67	77
133	13502150	2	31	F	20.79	137	324	7.5	18	0.77	220	185	48	202	18	10.8	9300	310000	28	1	13.87	72
134	16480102	2	36	M	29.43	186	240	8.1	32	0.75	213	139	48	208	25	14.3	9900	267000	9	0	7.8	77
135	20440636	2	50	F	18.59	140	208	8.5	28	0.7	219	174	44	211.8	18.9	12.1	6700	298000	16	0	5.67	82
136	21060520	2	47	F	25.31	117	290	8.6	26	0.45	165	144	42	210	18.8	11.3	7100	345000	11	0	7.45	81
137	14525129	2	39	M	26.56	152	292	8.5	18	0.48	134	204	48	180	25.6	15.4	6300	234000	31	0	10.11	84
138	14397582	2	45	M	28.67	117	259	7.1	28	0.62	174	134	51	185	22.4	12.4	5900	213000	19	0	4.13	89
139	24406363	2	51	M	29.24	132	238	6.9	36	0.54	187	140	43	194	26.7	10.3	8800	267000	12	0	11.56	66
140	15798984	2	38	M	29.06	187	240	6.7	32	0.48	198	86	34	174	27	14.4	7600	321000	15	0	3.99	62

POST INTERVENTION GROUP

SL. NO	IP NO	GROUP	AGE (YEARS)	SEX	POST-BMI	POST-FBG mg/dl	POST-PPBG mg/dl	POST-HBA1c %	POST-Urea mg/dl	POST-Creat mg/dl	POST-LDL mg/dl	POST-TG mg/dl	POST-HDL mg/dl	POST-CHL mg/dl	POST-VLDL mg/dl	POST-Hb %	POST WBC/Cumm	POST-PLT cells/cumm	POST-ESR mm/hr	POST-Urine glucose	POST-U micro albumin mg/l	POST S.ZINC micro g/dl
																	7400	210000	21	1	3.22	65
1	15802407	1	45	F	25.53	130	210	7.1	20	0.76	54	84	52	118	15	11.20 %	6700	320000	47	0	6.8	60
2	13262803	1	39	F	24.06	156	268	6.5	28	0.31	55	82	41	180	22	11	5400	320000	45	1	7.6	64
3	21169635	1	50	M	29.54	134	261	7.3	40	0.38	128	109	50	188	31	12.2	6400	245000	53	0	5.2	67
4	15418904	1	38	F	27.64	154	278	6.8	42	0.44	88	96	47	178	22	9.6	4900	265000	39	0	7.6	72
5	15460918	1	29	M	27.6	160	230	8.3	20	0.58	114	104	50	192	21	12.8	5400	245000	45	0	3.7	88
6	1953258	1	49	F	30.8	156	213	6.6	42	0.52	88	88	66	167	32	12.4	7000	265000	48	1	1.45	91
7	17220654	1	46	F	26.06	134	234	6.4	38	0.54	112	93	48	222	42	12	6500	345000	21	0	6.5	46
8	13694195	1	47	M	23.04	177	254	7.1	30	0.53	98	87	50	245	30	11	5300	330000	26	0	7.3	55
9	15671377	1	56	F	22.53	142	175	7.6	34	0.74	94	107	43	190	26	12	6900	234000	32	0	1.4	72
10	11886089	1	58	M	30.53	153	224	6.4	34	0.61	102	98	61	154	24	11.2	5200	245000	36	1	6.6	62
11	15246133	1	65	F	33.98	176	245	6.4	46	0.54	96	86.5	49	172	47	12	5900	365000	27	0	2.24	55
12	17770034	1	35	M	27.6	185	270	6.2	33	0.64	112	92.5	54	177	42	11	4900	360000	6	0	7.8	59
13	21137046	1	56	F	28.88	129	267	6.9	34	0.71	108	118	48	182	36	10.2	8900	375000	24	1	5.6	74
14	12846025	1	67	F	29.41	156	267	7.5	19	0.54	111	118.8	42	164	38	12.7	5900	250000	17	0	1.48	72
15	14644613	1	57	M	27.08	165	209	7.3	26	0.46	114	230.6	43	176	32	12	6400	265600	16	1	5.67	66
16	12233560	1	58	F	23.13	156	240	8.9	28	0.48	120	222	38	166	28	9.9	5400	260000	32	0	6.7	63

17	13890074	1	54	M	31.15	151	198	8.2	32	0.76	108	123	45	165	27	9.8	9000	290000	90	0	5.64	103
18	11935914	1	60	F	29.41	196	241	7.1	33	0.84	88	146	50	182	31	10.2	7300	254000	9	0	5.6	93
19	12817186	1	54	F	29.4	154	209	8.2	34	0.47	92	99	44	184	42	11	6500	360000	23	0	8.6	88
20	21668962	1	48	M	30.9	173	208	8	36	0.8	86	94	65	157	43	12	7900	350000	14	1	5.9	73
21	20026778	1	54	F	21.3	180	265	7.9	32	0.8	88	87	44	177	20	9.8	5900	241000	19	1	3.22	72
22	21668926	1	44	F	25.6	190	209	6.9	22	0.9	56.8	85	48.6	126	18	11	7200	294000	37	0	5.6	70
23	20026877	1	38	M	30.08	101	209	6.5	18	0.61	116	79	40	166.8	16	10.9	6500	250000	24	0	7.6	72
24	12597961	1	38	M	29.06	121	235	7.1	26	0.54	84	124	50	154	18	11.6	6400	254000	24	0	4.67	62
25	20393376	1	50	F	32.4	122	201	6.9	30	0.86	110	94	48	148	21	11	7900	320000	35	2	8.98	65
26	21628703	1	44	M	26.53	156	280	8	32	1.02	90	103	49	168	18	11	8900	360000	10	0	10	63
27	17151241	1	47	F	34.9	124	209	7	34	0.59	106	92	65	208	16	13	5600	320000	25	0	6.98	62
28	16644988	1	40	M	28.85	121	246	7.1	22	0.66	108	83	48	168	17	14	7500	250000	20	0	6.5	76
29	117211049	1	49	M	29.8	126	198	7.2	24	0.56	115	125	56	192	25	11.6	7500	360000	27	0	6.82	60
30	13266624	1	47	F	30.41	128	223	6.4	27	0.58	103	132	45	202	16	12.6	9000	350000	18	0	5.6	77
31	17211049	1	29	M	29	166	309	7.2	36	0.65	97	88	67	196	17	12	7100	250000	29	0	8.4	82
32	13664566	1	46	F	23.18	145	209	7.1	32	0.48	76	82	46	154	26	14	4500	320000	6	0	6.7	77
33	17211049	1	47	M	32.9	145	260	7.2	38	0.62	79	87	50	168	23	13.6	6200	320000	19	0	7.8	62
34	13226656	1	56	F	24.6	130	207	6.9	28	0.51	93	95	46	188	26	14.2	7500	300200	20	0	7.4	63
35	17211049	1	43	M	25.83	124	194	6.2	32	0.68	88	122	44	186	24	14.4	11000	300000	18	1	6.5	62
36	14499464	1	57	F	29.04	189	215	8.3	28	0.6	92	243	48	174	52	12	8000	273000	20	0	1.48	57
37	14431445	1	52	M	29.8	178	267	7.2	22	0.7	80	104	46	149	26	13	9600	360000	9	0	2.24	66

38	20718112	1	53	F	26.5	152	265	6.3	16	0.64	104	127	40	152	26	14.4	9500	312000	17	2	7.8	62
39	16798901	1	45	F	30	130	192	7.1	34	0.72	95	118	52	163	22	11	7000	250000	11	0	3.56	98
40	16075225	1	52	F	24.1	149	219	7.2	16	0.66	78	101	43	158	32	14	5400	275000	31	0	5.67	74
41	21639157	1	48	M	28.39	138	215	6.9	32	0.64	83	156	63.4	164	24	12	7500	250000	19	0	6.6	76
42	20855170	1	50	F	25.48	156	228	7.2	25	0.62	92	89	48	133	15	11.6	7000	310000	12	0	6.8	75
43	16798901	1	35	M	25.9	130	200	6.9	30	0.62	72	86	52	127	15	12	7400	260000	10	0	7.47	66
44	16015225	1	50	M	26.2	145	235	7.3	22	0.76	120	114	54	203	22.4	15	6300	350000	14	0	7.8	71
45	21639157	1	41	M	30.1	126	206	6.9	22	0.92	97	159	53	189	32	12	6800	350000	13	0	7.4	62
46	20855170	1	48	F	28.01	167	234	7	21	0.88	98	108	48	211	28	12	7200	250000	24	1	6.7	83
47	1459800	1	38	M	24.57	127	232	7.4	36	0.39	81	112	55	197	27	12.6	8500	350000	22	0	8.4	85
48	12831804	1	44	M	25.38	209	231	8.2	28	0.58	79	106	61	178	25	12	5200	332000	17	1	4.2	82
49	14595800	1	58	F	26.83	123	207	6.9	20	0.73	101	77	41	132	18	11.4	8000	350000	20	0	4.4	88
50	12838104	1	39	F	28.4	217	256	7.2	28	0.61	110	146	52	213	29	12	5200	322000	20	1	3.28	81
51	21665478	1	44	M	27.9	166	208	7.1	23	0.56	108	99	46	122	22	8.8	4800	302000	21	0	4.67	85
52	14385636	1	56	M	24.29	152	276	7.8	22	0.67	66	101	45	191	24	9	6400	250000	29	0	4.21	72
53	21283778	1	48	F	31.5	123	203	6.9	24	0.56	92	97	47	151	18	10	7500	210000	39	0	5.6	67
54	16648686	1	47	M	30.06	136	243	7.1	29	0.65	75	92	53	162.1	19	13	6800	260000	24	0	10.4	60
55	21309276	1	48	F	33.4	126	208	7.2	32	0.72	112	115	45	182	26	12	7500	378000	18	0	8.88	67
56	20522554	1	63	F	24.5	129	227	7.1	28	0.65	102	102	42	173	24	13.5	6400	260000	21	1	3.22	69
57	16317857	1	29	F	34.8	134	205	7.1	22	0.79	58	87	59	116	19	11	7200	230000	34	0	6.88	59
58	20522554	1	46	M	27.5	109	220	6.3	24	0.68	122	85	44.6	166.4	17	10.2	5900	210000	23	0	7.88	62

59	16317857	1	47	F	27.65	121	245	7.2	26	0.82	89	124	54	146	18	11	7000	200000	26	0	4.67	71
60	17642561	1	53	M	30.1	114	186	6.4	32	0.72	109	98	48.6	144	21	10.4	8500	250000	40	0	8.98	62
61	20758111	1	43	F	27.08	123	243	7.5	36	0.76	93	103.6	52	171	24	10.2	8000	214000	10	0	10.3	69
62	20319047	1	57	M	24.8	129	209	6.3	37	0.6	106	96	66	212	23	13	5200	321000	20	0	6.98	70
63	20522541	1	52	F	32.5	129	202	6.9	22	0.62	107	88	53	165	33	14.5	7000	250000	21	0	5.3	62
64	21787011	1	53	M	24.86	120	209	6.9	20	0.56	118	145	58	188	24	10.3	8200	290000	30	0	5.6	89
65	20640387	1	45	F	26.9	143	204	6.3	26	0.8	113	125	41.6	193	31	13.1	7500	301000	22	0	5.6	76
66	22008912	1	56	M	27.4	136	237	7.2	40	0.63	104	87	67	183	24	11	8000	320000	24	0	8.3	70
67	20640387	1	38	F	25.8	146	205	7.1	28	0.61	82	93	54	154	37	11.5	4800	312000	6	0	6.7	62
68	21787011	1	45	M	27.8	127	210	7.1	42	0.65	78	79	55	172	15	12.5	8000	350000	20	0	7.2	63
69	20640387	1	58	F	28.8	109	203	6.2	27	1.1	99	94	56	174	22	14.4	8700	300000	22	0	8.66	89
70	22008912	1	51	M	29.1	147	199	6.5	22	1.02	102	119	49	182	19	14	7900	244010	18	0	6.5	81
71	21767662	2	44	M	31	198	215	8.9	28	0.9	97	266	56	182	32	12	8500	450000	24	0	1.48	77
72	17130038	2	38	M	26.3	120	206	7.1	18	0.84	85	103	45	160	31	13.7	9000	218000	9	0	2.24	83
73	11189548	2	38	F	26.1	102	127	6.3	16	0.6	120	130	52	166	27	13.3	8900	262000	16	1	11.3	64
74	21137719	2	50	F	28.5	130	192	7.2	32	0.8	105	119	65	172	18	11	7500	320000	11	0	3.56	68
75	15583252	2	44	M	29.8	167	201	7.3	12	0.54	86	98	53	163	20	14	6000	164000	31	0	5.67	69
76	11989862	2	47	F	26.1	138	205	7	32	0.81	93	166	72	174	16	12	7600	230000	19	0	8.64	63
77	17124908	2	40	M	39.5	136	290	7.2	22	0.58	85	90	52	144	27	11	8000	191000	12	0	6.8	63
78	21859096	2	49	F	25.3	123	198	6.9	16	0.56	78	83	57	132	25	10.5	8500	350000	19	0	7.47	62
79	21895069	2	47	F	33	125	205	7.2	19	0.71	112	119	64	214	55	15	7800	318000	14	0	7.8	62

80	12739185	2	29	F	21.9	126	196	6.9	27	0.56	105	167	62	197	17	12	7200	256000	13	0	8.99	61
81	11346370	2	46	M	34.51	127	202	7.2	23	0.65	108	110	56	213	42	11.7	7000	216000	24	1	6.7	63
82	16648686	2	47	M	24.61	126	220	7.8	32	0.54	87	113	59	216	15	12.8	7000	280000	22	0	8.4	73
83	16888211	2	53	F	24.8	202	284	8.9	36	0.68	85	111	63	172	26	12.9	6000	250000	17	1	4.2	66
84	16595726	2	43	F	29.41	102	244	6.9	22	0.55	99	78	54	132	28	11.2	8500	282000	24	1	4.4	63
85	21249528	2	57	F	30.64	200	204	7.2	31	0.71	101	144	64	203	32	11.5	5200	211000	20	1	3.28	69
86	17037224	2	52	M	25.77	149	284	7.1	32	0.66	108	99	44	127	46	8.6	5400	220000	21	0	4.67	65
87	17230819	2	53	F	23.57	121	223	7.8	27	0.72	77	104	56	186	18	9.9	8700	260000	32	0	4.21	69
88	21822062	2	45	M	26.9	143	206	6.9	26	0.79	88	108	57	149	23	10.1	6800	328000	34	0	5.6	68
89	13894911	2	52	M	26.29	147	164	7.5	34	0.84	77	89	63	163	22	12	7500	202000	24	2	11	73
90	21574188	2	48	M	27.5	156	207	7.4	38	0.9	109	114	54	174	19	12.4	8000	310000	18	0	6.7	72
91	13502105	2	50	M	28.9	121	209	7.2	29	0.75	103	95	53	163	19	13	8700	323000	34	1	4.55	68
92	15751154	2	35	M	29.3	154	293	7.1	24	0.8	97	90	51	167	18	14	6800	210000	34	0	5.3	63
93	14525119	2	50	F	27.2	130	197	7.2	36	0.9	99	94	47	158	22	11	8500	210000	45	0	9.3	60
94	14398572	2	41	F	26.61	124	297	7.7	28	0.6	92.4	103	53	166	17	12	9600	240000	32	1	5.88	63
95	15759898	2	48	M	25.7	164	201	6.9	18	0.59	102.6	112	55	186	18	13	8500	267000	34	2	11	66
96	1277314	2	38	F	35.51	124	247	7.1	41	0.6	120	91	49	193	17	10	6500	256000	28	0	8.8	69
97	22216735	2	44	M	27.92	129	203	6.9	38	1.3	114	96	63	114	16	14	7500	298000	16	0	10	68
98	16809812	2	58	F	27.2	103	293	8.2	21	0.49	84	92	52	203	17	13	6900	254000	19	0	9	67
99	23045720	2	39	F	25.6	154	203	7.5	22	1.02	122	117	49	213	26	12	8400	234000	40	0	7.89	72
100	11719288	2	44	F	25.73	294	234	7.8	28	0.74	118	134	48	195	18	12	8600	230000	30	0	8.6	71

101	15226280	3	2	56	M	28.04	109	191	7.2	22	0.63	106	93	47	166	16	14.6	8400	280000	10	0	11	79
102	15226280	3	2	48	F	32.2	126	200	6.3	26	0.52	122	87	54	1169	25	12	5900	264000	18	0	6.7	101
103	15893981	3	2	47	F	29.5	150	207	6.9	32	0.71	108	86	52	173	24	13	5900	258000	26	0	12	72
104	22346647	3	2	48	M	24.3	144	191	7.2	42	0.56	105	92	48	159	28	14.2	5800	278000	16	0	6.8	78
105	15618182	3	2	63	F	19.4	151	266	8.5	38	0.53	90	106	44	172	25	12	8500	239000	23	0	7.3	72
106	22760164	3	2	44	M	23.53	154	189	7.8	30	0.66	77	136	47	166	44	9.4	7100	376000	34	0	6.2	76
107	16268641	3	2	52	F	24.61	121	218	7.2	14	0.58	101	91	46	174	22	11	8000	265000	19	0	8.4	71
108	12836218	3	2	64	M	25.2	109	278	8.2	22	0.65	95	106	42	173	21	13.8	5400	253000	21	2	6.3	77
109	20659906	3	2	52	F	32.67	121	209	6.4	18	0.88	84	92	54	158	24	11.5	9000	310000	17	0	6.8	76
110	20287401	3	2	62	M	31.6	129	178	6.5	18	0.54	107	88	48	168	30	14.4	6500	159000	26	0	3.2	79
111	20050082	3	2	45	F	27.71	155	260	8.4	27	0.78	83.5	144	68	165	20	12.8	7200	320000	26	0	11	81
112	17019822	3	2	64	M	27.61	202	219	7.32	17	0.6	108	92	53.4	144	26	9.8	6800	186000	16	0	8.9	75
113	11748724	3	2	29	F	17.6	122	333	9.3	26	0.4	112.8	90	54	205	12	8.8	6400	320000	10	0	8.4	71
114	21548941	3	2	65	M	28.4	198	231	7.9	30	0.8	73	93	61	178	22	11.4	7500	310000	22	0	2	109
115	13491258	3	2	48	F	30.4	176	239	8.3	28	1.1	110	137	56	194	32	13.2	8900	284000	9	0	8	99
116	14754383	3	2	50	M	26.81	126	178	6.2	27	0.49	72	102	53	188	28	9.4	7800	247000	23	1	8.2	89
117	20039204	3	2	60	F	26.3	128	290	11	25	0.47	124	99	58	158	27	11	5800	238000	30	2	6.34	76
118	21137361	3	2	66	M	28.06	106	195	6.5	26	0.7	100	106	64	143	23	11.2	6000	274000	22	1	6.89	72
119	22123711	3	2	38	F	21.7	103	273	10	15	0.82	111	87	48	168	18	12	7800	239000	18	2	11	72
120	15695276	3	2	45	F	27.6	108	192	7.5	22	0.61	160.6	127	67	135	27	15	9000	243000	23	1	9.85	75
121	21425927	3	2	48	M	27.4	129	239	6.5	27	0.38	130	106	46	175	22	12.1	6800	222000	10	0	5.5	79

122	17741710	2	50	F	26.32	143	148	6.9	18	0.72	112	97	45	157	24	15.1	9000	244000	20	0	3.66	89
123	2538017	2	65	M	28.7	240	270	7.2	32	0.37	107	99	52	164	17	10.4	8000	277000	29	0	2.8	79
124	20117052	2	46	M	25.5	129	245	8.5	28	0.56	99	88.6	47	174	16	12.4	7200	206000	18	2	5.18	92
125	21950232	2	44	F	25.91	123	208	6	18	0.68	72	98	46	156	27	13	6800	208000	24	0	6.76	108
126	17037422	2	36	F	28.4	101	226	7	34	0.66	86	102	56	173	23	12.7	9400	310000	22	1	5.45	99
127	17230198	2	29	M	22.8	221	226	6.9	18	0.65	113	140	55	188	19	11.6	6700	283000	33	0	7.89	91
128	21822620	2	38	F	21.6	193	222	7.5	22	0.74	95	103	64	166	16	12	6900	243000	6	0	7.9	85
129	13894918	2	50	F	27.44	121	240	6.9	27	0.65	101	97	58	171	21	11.8	9000	341000	20	0	6.78	87
130	21541788	2	39	M	25.6	142	228	7.4	25	0.62	123	106	42	156	19	11	7900	210000	22	2	12.4	86
131	13984912	2	60	M	27.2	122	360	7.5	32	0.54	148	95	55	158	18	11.7	8500	247000	18	0	6.3	81
132	21578144	2	52	F	19.3	154	291	7.9	43	0.42	157	88	43	152	21	15.2	8000	320000	22	0	11	81
133	13502150	2	31	F	21.9	117	224	7.4	26	0.65	170	175	53	187	19	11	8600	267000	9	0	7.8	81
134	16480102	2	36	M	29.9	156	202	7.4	44	0.66	192	128	65	178	22	14	6700	298000	16	0	5.67	88
135	20440636	2	50	F	18.59	120	198	8.2	32	0.64	181	167	66	192	17.4	12	8000	345000	11	0	7.45	84
136	21060520	2	47	F	25.31	117	290	8.2	28	0.32	155	138	44	182	17.4	11	7300	234000	22	0	9.4	87
137	14525129	2	39	M	26.56	152	292	8.2	22	0.63	112	189	52	168	22.4	15.5	6000	260000	19	0	4.13	91
138	14397582	2	45	M	28.67	117	259	6.9	32	0.54	158	127	55	174	21.6	12	9000	267000	12	0	8.9	70
139	24406363	2	51	M	29.24	132	238	6.5	34	0.65	162	131	46	166	24.6	10.1	8900	321000	15	1	2.4	69
140	15798984	2	38	M	29.06	187	240	6.4	41	0.17	176	87	44	162	23	14.6	9100	310000	19	0	3.3	70