THE EFFECTS OF 24 WEEKS OF CHROMIUM SUPPLEMENTATION ON GLUCOSE INTOLERANCE IN MEN

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CHAPTER I

INTRODUCTION

Research Problem

Diabetes mellitus affects 15.7 million people in the United States, with 2,200 new cases diagnosed each day. Diabetes is the seventh leading cause of death in the United States, and as of today there is no cure (American Diabetes Association, 2001).

There are two types of diabetes. Type 1 diabetes is a condition where the body no longer makes insulin. People with Type 1 diabetes must take regular insulin to survive. Type 1 diabetes is usually diagnosed in children or young adults. Type 2 diabetes is a condition where the body is not producing sufficient insulin or the body is not using the insulin it produces effectively. Type 2 diabetes is generally diagnosed in adulthood, and accounts for 90-95% of the diabetes cases in the United States (American Diabetes Association, 2001).

The American Diabetes Association has outlined several risk factors for Type 2 diabetes. People who are at the highest risk for developing Type 2 diabetes are people over the age of 45 who are overweight, have a family history of diabetes, lead sedentary lifestyles, and have high triglycerides and low HDL cholesterol levels. Some ethnic groups are also at higher risk for developing Type 2 diabetes, such as Native Americans, African Americans, and Latinos.

Many complications can result from undiagnosed or uncontrolled diabetes, such as blindness, kidney disease, and nerve disease. These complications arise due to damage

to the small blood vessels. Heart disease and stroke are complications that can arise due to long-term damage to the large blood vessels (American Diabetes Association, 2001).

The health care costs for diabetes, along with the indirect costs of diabetes such as lost wages, are approximately $98 billion a year (American Diabetes Association, 2001). This dollar figure makes research to lower the incidence of diabetes worthwhile.

Glucose intolerance is a condition of impaired glucose levels that may precede Type 2 diabetes. Chromium, an essential mineral required for normal blood glucose regulation, has been shown to improve glucose tolerance in people with Type 2 diabetes (Mahdi et al., 1991). Although its role in glucose tolerance is controversial, chromium supplementation has been shown to increase insulin efficiency by increasing the number of and/or the effectiveness of insulin receptor sites, and increasing insulin binding (Anderson, 1992). Increased insulin sensitivity could result in improved glucose tolerance, which may help avoid or delay the onset of Type 2 diabetes.

Purpose

Since past chromium research has included either healthy people or people already diagnosed with diabetes, the current study targeted people with glucose intolerance. If glucose intolerance can be treated successfully, Type 2 diabetes onset may be delayed or avoided in people who first experience glucose intolerance. The purpose of this study was to examine the effects of 24 weeks of chromium supplementation with 200 μg chromium per day as chromium chloride on three-hour glucose and insulin curves, glycosylated hemoglobin, and percent specific insulin binding following a 75g oral glucose load in glucose intolerant men.

Null Hypotheses

The following are the null hypotheses for this study:

1. There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on 3-hour serum glucose curves following a 75 g oral glucose load among glucose intolerant men.
2. There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on 3 hour serum insulin curves following a 75 g oral glucose load among glucose intolerant men.
3. There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on glycosylated hemoglobin concentration among glucose intolerant men.
4. There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on percent specific insulin binding among glucose intolerant men.

Assumptions

The following assumptions were made for this research:

1. Participants did not alter their exercise and eating habits during the course of the study.
2. Participants took one supplement daily for 24 weeks.
3. Participants fasted for twelve hours prior to each blood collection.
4. Participants did not take any other nutritional supplement that contained chromium during the course of the study.

Limitations

1. The one week food frequency was limited by the participants' knowledge and understanding of food composition and portion sizes.
2. The dietary analysis was limited due to an inadequate database for chromium.
3. The results of this study are limited by outside factors affecting participants such as illness, change in medication, and surgery.
4. The results of this study are limited by the tendency of health conscious individuals to volunteer for this type of research.
5. The results of the study are representative of this sample, and therefore cannot be applied to the general population.

6. A crossover design, which would have provided a larger number of supplemented individuals, could not be done due to the length of the study for that design, and the possible problems with compliance.

CHAPTER II

REVIEW OF LITERATURE

Diabetes mellitus

Diabetes mellitus is a disease that affects millions of people in the United States. In 2001, it was estimated that 15.7 million people in the United States had diabetes, with only 10.3 million of those cases being diagnosed (American Diabetes Association, 2001). Type 2 diabetes is the most prevalent form of diabetes, and accounts for 90 to 95% of all cases. Type 2 diabetes, previously known as adult onset diabetes, occurs when the body is not producing sufficient insulin, or when the body is not using the insulin it produces effectively (American Diabetes Association, 2001).

There are several risk factors for the development of Type 2 diabetes. People who are overweight, over the age of 45 and who have a family history of diabetes have a higher risk of developing Type 2 diabetes. Obesity is one of the biggest risk factors for the development of Type 2 diabetes (Everhart et al, 1992). The incidence of Type 2 diabetes drops as BMI (body mass index) decreases, and it is suggested that people with Type 2 diabetes try to reduce their BMI to between 20 and 25 (American Diabetes Association, 2001). Weight loss in individuals with Type 2 diabetes has been shown to improve insulin sensitivity and insulin binding to its receptor sites (Pi-Sunyer, 1996). For individuals who are overweight, the American Diabetes Association recommends weight loss, even 10 or 20 pounds, as one way to keep Type 2 diabetes under control or to possibly prevent the onset of Type 2 diabetes (American Diabetes Association, 2001). Age is also be a factor in the development of Type 2 diabetes. As people age, there is a

tendency for increased adiposity and increased central obesity (Pi-Sunyer, 1996). This increase in body fat increases the risk for developing Type 2 diabetes. As a reflection of these risk factors, the incidence of Type 2 diabetes is increasing in the aging population, as well as among people who are obese and sedentary for all ages (American Diabetes Association, 2001).

Type 2 diabetes can lead to many health complications, especially if left uncontrolled. Complications resulting from uncontrolled diabetes include damage to the small blood vessels, which can cause blindness, kidney disease, nerve damage, amputations, and impotence in men (American Diabetes Association, 2001). Uncontrolled diabetes can also increase the risk of cardiovascular disease and stroke due to large blood vessel damage (American Diabetes Association, 2001).

Many times, these complications can lead to costly hospital stays and other expensive treatment that could possibly be avoided. In 1997, the health care cost for diabetes was estimated at $98 billion (Centers for Disease Control, 1999). This figure includes both direct costs such as inpatient care, which accounts for $44 billion, and indirect costs, such as lost productivity, premature death, and disability, which account for $54 billion (Centers for Disease Control, 1999). Some of these costs could be decreased if the onset of diabetes could be delayed or completely avoided.

Type 2 diabetes can be diagnosed in three ways, according to the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2000). First, an individual may be diagnosed with diabetes if he or she has some symptoms of diabetes, as well as a plasma glucose concentration of greater than or equal to 200 mg/dl. In this

case, the plasma glucose concentration is measured at any time of day with no consideration given as to the time the last meal or snack was consumed. It is important to note that symptoms of diabetes must also exist in addition to this plasma glucose concentration, such as polydipsia and polyuria. Diabetes may also be diagnosed if an individual has a fasting plasma glucose concentration of greater than or equal to 126 mg/dl. Fasting, in this case, refers to no caloric intake for at least 8 hours prior to the testing. Finally, the third option for the diagnosis of diabetes is a 2-hour plasma glucose concentration of greater than or equal to 200 mg/dl following an oral glucose tolerance test. The committee recommends following the World Health Organization (WHO) guidelines for the oral glucose tolerance test, which include the use of 75g anhydrous glucose dissolved in water (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2000).

Glucose intolerance often precedes the development of Type 2 diabetes. Glucose intolerance is a condition in which fasting glucose is less than 126 mg/dl, which is considered normal, but plasma glucose concentration 2 hours after an oral glucose challenge is between 140 mg/dl and 200 mg/dl, which is considered to be elevated (American Diabetes Association, 1997). Some studies have reported supplemental chromium improves glucose concentrations among individuals who have diabetes (Wallach, 1985). If adequate chromium intake can improve glucose concentrations in glucose intolerant individuals, Type 2 diabetes onset could possibly be avoided or delayed (Anderson, 1992).

Chromium

Chromium, which is a "white, hard, brittle metal of the first transition series," can exist in many states. The most common oxidation states in which chromium exists are 0, +2, +3, and +6 (Borel and Anderson, 1984). Of these states, the most stable of these is the trivalent state (Stoecker, 1990).

Vauquelin first discovered chromium in 1797 (Baruthio, 1992). It was originally used in industry for several purposes, such as leather tanning and for pigmentation (Baruthio, 1992). Schwarz and Mertz discovered chromium's biological functions in 1957, and suggested the essentiality of chromium in the human diet. This breakthrough introduced chromium to the health care world (Schwarz and Mertz, 1959).

Chromium itself acts to "potentiate the action of insulin" in the body (Borel and Anderson, 1984). In 1957, Schwarz and Mertz observed impaired glucose tolerance in rats was improved due to a substance in brewer's yeast. This substance was found to be trivalent chromium (Schwarz and Mertz, 1959). For many years, this action was known as the glucose tolerance factor, or GTF.

Chromium deficiency symptoms can include fasting hyperglycemia, impaired glucose tolerance, elevated serum cholesterol and triglycerides, decreased insulin binding, and decreased insulin receptor number. These symptoms have been shown to improve in many studies with chromium supplementation (Anderson, 1993).

Deficiency of trivalent chromium has been noted and studied, however, toxic effects are mainly limited to the hexavalent compounds. The human body absorbs these compounds easily in both the lungs and the digestive tract (Baruthio, 1992). Toxicity

symptoms can include ulceration, pain and itching of the skin, ulceration of the nasal septum, discoloration of the teeth, and certain types of cancer (Baruthio, 1992).

Borel and Anderson (1984) reported that dietary chromium intake of normal individuals often is less than the minimum suggested intake. Even certain diets that are accepted as well-balanced contain only 5 to 10 μg chromium (Cr) per 1,000 calories (Anderson et al., 1997). This intake is well under the Adequate Intake recommendations of 35 μg chromium/day for men and 25μg chromium/day for women when average calorie intake is taken into account (Institute of Medicine, 2001). For example, a woman would need to eat a balanced diet that contained between 2,500 and 5,000 calories per day to reach this recommendation. In addition, Schroeder et al. reported the chromium content of foods decreases with refining and processing (Schroeder, 1971). Many Americans consume a majority of foods that are refined or processed in some way, thereby reducing the chromium content.

It is important to note that this study was conducted under the recommendation of 50-200 μg chromium per day for adults, which was the estimated safe and adequate daily dietary intake (ESADDI) for chromium at the time this study was conducted(National Research Council, 1989). The new dietary recommended intake (DRI) for chromium was released in January of 2001. The new Adequate Intake (AI) for chromium was set at 25 μg chromium per day for women and 35 μg chromium per day for men. No upper limit was set (Institute of Medicine, 2001).

Chromium and Glucose Tolerance

Chromium has been proven to be essential in both humans and animals (Borel and Anderson, 1984). A study by Schwarz and Mertz demonstrated the essentiality of chromium in rats. In this study, rats fed a "stock diet" deficient in chromium resulted in impaired glucose tolerance. When yeast containing chromium was added to the diet, the rats' glucose concentrations returned to normal (Schwarz and Mertz, 1957). The essentiality of chromium in humans dates back to a case study by Jeejeebhoy et al. in 1977. This case study evaluated a patient on long-term total parenteral nutrition (TPN) who developed symptoms of diabetes including hyperglycemia and unexplained weight loss. These symptoms were corrected with the addition of chromium to the TPN solution, which had not previously contained chromium (Jeejeebhoy et al., 1977). This study and other studies on long-term TPN patients show the necessity of adding chromium to TPN solutions as a standard, but TPN patients are not the only people at risk for chromium deficiency. Due to the low chromium content in the typical American diet and increased chromium losses due to refining and processing, many people may be at risk for inadequate chromium intake (Borel and Anderson, 1984).

Conflicting results have been reported regarding the effects of chromium supplementation on glucose and insulin concentrations. Research representing both sides of these findings has been conducted on many species including, but not limited to, rats and humans.

Several studies have reported beneficial effects of chromium supplementation on blood glucose and/or insulin concentrations. In a study published by Anderson et al., 180 people with Type 2 diabetes were given either a placebo or one of two different levels of

chromium supplementation. The patients who participated in the study had to be between 35 and 65 years of age, free of disease other than Type 2 diabetes, have a fasting glucose concentration of 7.2-15.5 mmol/l, have a 2-hour blood glucose concentration of 9.4-16.7 mmol/l, and have a HbA_{1c} level of 8.0-12.0%. The 180 participants were randomly divided into three groups of 60. The first group received a placebo, the second group received 1.92 μmol of chromium twice per day, and the third group received 9.6 μmol of chromium twice per day. The chromium was given in the form of chromium picolinate, and the participants were encouraged to take the supplements once in the morning and once in the evening between meals. Medications were held constant during the study, and the participants were encouraged not to deviate from their normal eating and exercise routines. At baseline and after 2 and 4 months of supplementation, serum glucose and insulin were measured at fasting and after a 2-hour glucose challenge using 75g glucose. Subjects who received 19.2 μmol chromium per day had significantly lower fasting and 2 hour serum glucose concentrations and fasting and 2 hour serum insulin concentrations at 2 and 4 months compared to placebo. The group receiving 3.85 μmol had a significantly lower fasting and 2 hour insulin concentrations compared to placebo, but no significant differences in serum glucose concentrations were observed (Anderson et al., 1997).

Fox and Sabovic reported a case study of a 28 year-old woman with Type 1 diabetes. The woman's HbA_{1c} value was 11.3% when supplementation with chromium picolinate was initiated. The woman received 600 μg chromium per day. The dosage was 200 μg chromium as chromium picolinate three times per day with meals. The participant self-reported improved home glucose concentrations three months after beginning supplementation, and these reported glucose concentrations "appeared to be about 30 to

60 mg/dl lower than corresponding values before she took chromium picolinate" (Fox and Sabovic, 1998). A repeat HbA_{1c} value after three months supplementation was 7.9%, which was an improvement of 2.4% over the pre-supplementation HbA_{1c} value. No other changes in her medications or lifestyle could explain her improved glucose control (Fox and Sabovic, 1998).

A study by Martinez et al. also reported beneficial effects of chromium supplementation on glucose tolerance. Eighty-five women between the ages of 59 and 82 participated in the study. Prior to the beginning of this study, participants were interviewed by research assistants to obtain background information on the use of prescription and non-prescription medications. Participants were randomly assigned to a chromium supplement or placebo group. The supplement group received 200 μg chromium as chromium chloride in a vial of distilled water daily. The placebo group received a vial of distilled water only. At baseline and 10 weeks after supplementation, plasma glucose was measured fasting and after a 2-hour glucose challenge with 75g glucose. Participants with plasma glucose concentrations greater than 100 mg/dl 2 hours after the glucose challenge at baseline were classified "at-risk for impaired glucose tolerance." The term "medicated" was used in this study to refer to participants using medications on a regular basis. When divided into "medicated" and "non-medicated" for the purposes of the study, the at-risk, non-medicated women in the chromium supplemented group had a significant decrease in 2-hour plasma glucose concentration compared to baseline. No significant effect on serum insulin concentration was observed after 10 weeks supplementation (Martinez et al, 1985).

Elias et al. conducted a study on the effect of chromium supplementation in diabetic patients. Four females and 2 males with Type 2 diabetes participated in this study. Participants were supplemented with three heaped tablespoons (about 52 g) of brewer's yeast a day for two weeks. The yeast contained 0.4 μg chromium per gram of brewer's yeast, which provided approximately 20.8 μg chromium per day. Baseline measurements were conducted on fasting serum glucose and insulin sensitivity using the artificial beta cell. Following two weeks supplementation, a significant increase in insulin sensitivity was observed. Although not significant, mean fasting serum glucose concentrations decreased for the participants (Elias et al., 1984).

Uusitupa et al. conducted a placebo controlled, double-blind, crossover study which involved supplementation with 200 μg chromium as chromium chloride. Ten participants with Type 2 diabetes (six men and four women) who had been treating their diabetes with diet therapy alone for at least 1 year participated in a 4-week run in period and two, 6-week supplementation periods. The run in period, which lasted 4 weeks, included no treatment or intervention. At the beginning and the end of the run-in period, and after 6 and 12 weeks supplementation, participants were tested for mean fasting blood glucose and serum insulin, 1-hour blood glucose and serum insulin, 2-hour blood glucose and serum insulin, and HbA_{1c} concentrations. During the first 6 weeks of supplementation, participants received either the placebo or chromium supplement, and the alternate treatment was given to participants in the final 6 weeks with no washout period. No significant differences were observed in the participants' mean fasting blood glucose or serum insulin, 1-hour blood glucose or serum insulin, 2-hour blood glucose or serum insulin, or HbA_{1c} concentrations when compared to the same values taken at

baseline. However, mean 1-hour blood glucose concentrations tended to be lower during the chromium supplementation period when compared to the placebo, but the results were not found to be statistically significant (Uusitupa et al., 1983).

Whereas some studies have reported beneficial effects of chromium supplementation on blood glucose or insulin concentrations, other studies have not reported beneficial effects with chromium supplementation. A crossover study by Lee and Reasner investigated the effect of chromium supplementation in 28 patients with Type 2 diabetes. Participants were between the ages of 32 and 65, and were comprised of both men and women who were randomly assigned to one of two groups. The study involved a supplementation period with either 200 μg chromium as chromium picolinate or a placebo for 2 months, followed by a washout period of 2 months in which no treatment was used. The washout period was followed by another supplementation period where the participants received the alternate capsule (chromium or placebo). Fasting serum glucose and HbA_{1c} were measured at baseline and every 2 months following until the study's end. No significant effect was observed in fasting glucose or HbA_{1c} values between the placebo or chromium supplementation periods (Lee and Reasner, 1994).

Abraham et al. also report no significant effect of chromium supplementation on fasting serum glucose concentrations. Seventy-six patients, the majority of which were men, were randomly assigned to either a supplement group receiving 250 μg of chromium per day as chromium chloride or a placebo group. The participants were 42 to 83 years of age, some were diabetic and some were not. Fasting glucose was measured at baseline, after three months supplementation, and at the end of supplementation for each participant, which ranged from 7 to 16 months. No significant effect was observed in

fasting glucose concentrations following chromium supplementation compared to baseline (Abraham et al., 1992).

In a study by Wilson and Gondy, 26 volunteers participated in a double-blind trial in which they were randomly assigned to either a chromium supplement group receiving 220 μg chromium as chromium (III) nicotinate, or placebo group for 90 days. Volunteers were excluded from the study if they had a history of chronic disease, if they had recently experienced a weight loss or gain greater than 10 pounds, or if they were a competitive athlete, dancer, or gymnast. Fasting glucose was measured at baseline and within one week of the end of supplementation. No significant effect was observed in fasting glucose concentrations after 90 days chromium supplementation (Wilson and Gondy, 1995).

The inconsistent results observed with chromium supplementation may be due in part to differences in subjects' health or chromium status. Chromium deficiency has been implicated as a possible cause of diabetes (Rabinowitz et al, 1983). As a result, healthy individuals with appropriate glucose tolerance and insulin sensitivity, or individuals who show no signs of marginal chromium deficiency would most likely not benefit from receiving additional chromium through supplementation (Anderson, 1992).

CHAPTER III

MATERIALS AND METHODS

Approval and Training

This study was approved by the Oklahoma State University Institutional Review Board for human subjects research (Appendix A). The researchers in the study were Dr. Janice Hermann, Joshua Phelps, and Rachael Condley. The researchers underwent both laboratory and radioactive materials safety training.

Population

Subjects were solicited by flyers mailed campus-wide and to community organizations (Appendix B). Flyers were also distributed throughout the community and advertisements were placed in the Stillwater NewsPress and the Daily O'Collegian, which is Oklahoma State University's daily newspaper for students, faculty, and staff (Appendix C). Adult males were solicited to screen for the study if they had one or more risk factors for developing diabetes; family history of diabetes, over 40 years of age, or overweight. Subjects interested in participating were screened for a fasting glucose concentration of <126 mg/dl and a 2-hour glucose concentration following a glucose load with 75 g dextrose between 130 and 199 mg/dl. Subjects who met the study criteria and were willing to participate had to be available to attend all of the data collection periods and had to be willing to stop taking any nutritional supplements containing chromium during the length of the study.

Screening

Subjects interested in screening for the study were asked to come to the Oklahoma State University Student Health Center following a 12 hour fast, but were advised to consume water. The subjects filled out an informed consent for the screening (Appendix D), and a health questionnaire (Appendix E). Height was measured to the nearest half-inch, and weight was measured to the nearest half-pound on a digital scale. Body Mass Index (BMI) was calculated using the equation; body weight (kg)/ height (m^2) (Meisler and St. Jeor, 1996).

Subjects received a finger stick fasting blood glucose test with a B-Glucose Photometer (HemoCue AB, Angelholm, Sweden) prior to administering a glucose challenge to identify anyone who might already be diabetic. Anyone with fasting blood glucose >126 mg/dl was counseled by a physician and was not given the glucose challenge. Subjects whose finger stick fasting glucose concentration was less than 126 mg/d; had a fasting blood sample drawn by a licensed phlebotomist in a 6 ml serum tube (Franklin Lakes, NJ). Subjects were then given a glucose tolerance beverage Trutol®, containing 75 g dextrose (Appendix F). A second blood sample was drawn into a 6 ml vacutainer serum tube (Franklin Lakes, NJ) two hours after consuming the Trutol®. Following the two-hour blood draw, subjects were given nutritional support that consisted of a small sandwich, chips, orange juice, and a muffin.

One hundred and twelve potential participants were screened for the current study, and 22 met the study criteria following the screening. Twenty subjects who met the study criteria of a fasting blood glucose concentration <126 mg/dl and a two-hour blood glucose concentration between 130 and 199 mg/dl following the glucose challenge

agreed to participate in the study. The subjects were matched into 2 groups based on their fasting serum glucose, two-hour serum glucose, age, and BMI. Matching was done to ensure that the groups were similar at baseline. Ten participants were placed into each group. The placebo or chromium supplement was randomly assigned to the groups.

Experimental Design

The research design was a pretest/posttest control group. This study involved two groups; a control group receiving a lactose placebo and an experimental group receiving a supplement containing 200 μg chromium as chromium chloride. Subjects were screened for eligibility, and those who met the study criteria were matched into 2 groups, which included a placebo group and a supplement group. The groups were matched based on age, BMI, fasting serum glucose concentration, and a 2 hour serum glucose concentration following a 75 g oral glucose load, which were measured at the screening. The treatment, placebo or chromium supplement was randomly assigned to the two groups. Data were collected at baseline and after 24 weeks supplementation. Data were collected in Stillwater, OK at the Oklahoma State University Student Health Center so the subjects would be in close proximity to a physician in case of an adverse reaction during the oral glucose challenge.

Supplements

The placebo and chromium supplements were prepared using a gelatin capsule filler machine (Quanterron, Inc., Burnsville, MN) in the Nutritional Sciences Laboratory

at Oklahoma State University. White number two gelatin capsules were used (Apothocary Product, Inc., Minneapolis, MN) so that the placebo and chromium supplements would appear similar.

Placebo supplements were filled with an average of 0.24g USP grade lactose (Spectrum Quality Products, Inc., Gardena, CA). Chromium supplements were prepared by mixing 2.05g USP grade $CrCl_3$-$6H_20$ (Spectrum Quality Products, Inc., Gardena, CA) with 477.95g USP grade lactose (Spectrum Quality Products, Inc., Gardena, CA). The chromium supplement mixture was mixed in a ball mixer (U.S. Stoneware, East Palesting, OH) for 24 hours to disperse the chromium throughout the lactose.

Both the chromium and the placebo supplements were analyzed for chromium content using atomic absorption spectrophotometer, Model 5100 PC (Perkin-Elmer Corp., Norwalk, CT). Eight 0.1g randomly chosen samples from the placebo and chromium mixtures were wet and dry ashed using a modification of the Hill et al. method (Hill et al., 1986). The average analyzed chromium content of the placebo was -0.484 μg/g. The average analyzed chromium content of the chromium supplement mixture was 658.275 μg/g. As a result, the fill weight of the chromium supplement was adjusted to 0.3038 g to provide 200 μg chromium per supplement.

Data Collection

Baseline Data Collection

Subjects who qualified and agreed to participate in the study were asked to participate in a baseline data collection process before beginning supplementation.

Subjects were asked to fast for twelve hours prior to the collection, but were encouraged to drink water. At the baseline data collection, subjects were asked to sign an informed consent for the study (Appendix G). Subjects were also instructed on and completed a 1-week food frequency, a modification of the Willetts food frequency questionnaire (Eck et al., 1991; Appendix H). Subjects' weight and height were measured to the nearest half-pound and half-inch, respectively. A fasting blood sample was drawn by a licensed phlebotomist in a 10 ml vacutainer serum tube and a 10 ml heprinized tube (Franklin Lakes, NJ), after which the subjects consumed a glucose drink Trutol®, which contained 75 g dextrose. Subjects had a blood sample drawn in a 6 ml vacutainer serum tube (Franklin Lakes, NJ) at 30, 60, 120, and 180 minutes after consuming the glucose tolerance beverage. Following the 180 minute blood draw, subjects were provided with nutritional support consisting of a sandwich, chips, muffins, and orange juice. Subjects received $150 for the baseline data collection.

One group of 10 men received the chromium supplement containing 200 μg chromium, which at the time of the study was at the upper end of the safe and adequate intake range (Stoecker, reference I need to get), once daily for 24 weeks. The other group of 10 received a placebo pill containing USP grade lactose only. The subjects received an individually delivered bottle of supplements each month containing more supplements than necessary for that month. Researchers counted the leftover pills after each delivery to establish compliance. Subjects were instructed to take one supplement per day with a meal.

Post Data Collection

After 24 weeks of supplementation, subjects were asked to come to a post-data collection following a 12-hour fast. At the post data collection, suspects were weighed and were asked to complete the one-week food frequency questionnaire. A fasting blood sample was drawn by a licensed phlebotomist in a 10 ml vacutainer serum tube and a 10 ml vacutainer heprinized tube, after which the subjects consumed a glucose tolerance beverage Trutol®. A 6 ml sample was drawn in a vacutainer serum tube by licensed phlebotomist 30, 60, 120, and 180 minutes after consuming the glucose tolerance beverage. Following the 180 minute blood draw, the subjects were provided with nutritional support. Subjects received $150 for participating in the post data collection.

Blood Handling

The same blood handling procedures were used at both the pre and post collections. Fasting blood collected in heprin tubes was kept on ice for 30 minutes. A 0.5 ml sample of whole blood was then removed and stored at –20°C in a parafilmed microcentrifuge tube for future analysis of glycosylated hemoglobin. Erythrocyte membrane ghosts were then obtained from the remaining heprinized blood using a methed developed by Dodge et al. (1963). The erythrocyte membranes were then stored at –70°C for future analysis of percent specific insulin binding and protein concentration.

Fasting, 30, 60, 120, and 180 minute serum tubes were kept on ice for 30 minutes, and then centrifuged to obtain the serum. Serum was then aliquoted and stored at –20°C in 0.5 ml parafilmed microcentrifuge tubes for future analysis of serum glucose and insulin.

Laboratory Analyses

Glucose

Serum glucose concentrations were analyzed using Roche Kit #47382 (Roche Diagnostic System, Inc., Branchburg Township, Somerville, NJ) on the COBAS FARA (COBAS FARA, Roche Diagnostic System, Inc., Montclair, NJ)

Insulin

Serum insulin concentrations were analyzed using DPC kit #2812 (Diagnostics Products Corporation, Los Angeles, CA) on the Gamma Counter (Packard Instruments Company, Downers Grove, IL).

Glycosylated Hemoglobin

Fasting whole blood glycosylated hemoglobin was analyzed by Roche kit #47212 (Roche Diagnostics Corporation, Indianapolis, IN) on the COBAS FARA. (COBAS FARA, Roche Diagnostic System, Inc., Montclair, NJ)

Percent Specific Insulin Binding

Right-side-out erythrocyte ghosts were prepared from erythrocytes using a method developed by Dodge et al (1963). The erythrocyte ghosts were used to determine percent specific insulin binding per 100 μg protein using a method developed by Gambhir and Bhathena (Gambhir et al., 1977; Bathena et al., 1989; Bathena et al., 1995).

Protein Concentration of Erythrocyte Ghosts

Protein concentrations of erythrocyte ghost samples were determined using BIO-RAD protein assay kit #500-001 (Los Angeles, CA) on the spectrophotometer (Beckman, Du 640 Spectrophotometer).

Anthropometrics

Height was measured to the nearest half-inch using a fixed measurement station set up at the baseline collection. Weight was calculated at both the pre and post data collections to the nearest half-pound on a digital scale. BMI (body mass index) was calculated using the equation body weight (kg)/ height (m^2) (Meisler and St. Jeor, 1996).

Food Frequency Analysis

The one week food frequency questionnaire was used to monitor for changes in participants dietary intake. The questionnaire was a modification of Willets one year food frequency (Eck et al., 1991). The one week food frequency questionnaires were analyzed using the Food Processor Plus Program (version 7.11, ESHA Research, Salem, OR). Standardized food codes were used throughout the study. The frequency forms were analyzed for kilocalories, protein, carbohydrates, total fat, and fiber.

Data Analysis

Data were analyzed using the Statistical Analysis System (SAS) repeated measures and least square mean procedures available at Oklahoma State University (SAS Inst. Inc., Cary, NC, 1999). The significance level for all testing was set at $p \leq 0.05$. The

effect of the independent variable, chromium supplementation, on the dependent variables, 3-hour serum and glucose curves following a 75 g oral glucose tolerance test, glycosylated hemoglobin, and percent specific insulin binding, were determined.

CHAPTER IV

RESULTS AND DISCUSSION

Results

Participants

Twenty participants, 10 in the chromium and 10 in the placebo group, participated in the study. Three participants were excluded from the final data analysis. One participant was found to be non-compliant due to missing the last month of supplements, and two participants failed to arrive for the post data collection. As a result, nine participants in the chromium supplementation group and eight in the placebo group were included in the final data analysis.

Age

No significant difference was observed based on t-test analysis between the mean age of the participants in the chromium group and placebo group (TABLE I). The chromium group had a mean age of 50 $\pm$ 3 years, while the mean age of the placebo group was 45 $\pm$ 4 years.

TABLE I.
Mean age, weight, and body mass index at baseline and after 24 weeks of supplementation with $CrCl_3.6H_20$ or a placebo*

	Chromium group (n = 9)		Placebo group (n = 8)	
	Baseline	Posttest	Baseline	Posttest
Weight (lbs)	248 $\pm$ 12	243 $\pm$ 11	237 $\pm$ 15	231 $\pm$ 17
Body Mass Index (kg/m^2)	34 $\pm$ 2	33 $\pm$ 2	33 $\pm$ 2	32 $\pm$ 2
Age (years)	50 $\pm$ 3		45 $\pm$ 4	

*Values are mean $\pm$ SEM

Weight

Repeated measures analysis of variance did not show a significant group by time interaction for total body weight (TABLE II). In the chromium group, the mean total body weight was 248 $\pm$ 12 pounds at baseline and 243 $\pm$ 11 pounds at posttest. The mean total body weight of the placebo group was 237 $\pm$ 15 pounds at baseline and 231 $\pm$ 17 pounds at posttest (TABLE I). Repeated measures analysis of variance did show a significant group effect, with the chromium group being an average of 11 pounds heavier than the placebo group at baseline and 12 pounds heavier than the placebo group at posttest (TABLE II). Although not significant, repeated measures analysis of variance showed a trend for a significant time effect on weight with baseline weight being higher than posttest weight for both groups (TABLE II).

TABLE II
Analysis of variance summary table for weight and body mass index after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Source of Variance	Probability
Weight	group	0.0010*
	time	0.0509
	group*time	0.8783
Body Mass Index	group	0.0012*
	time	0.0507
	group*time	0.8078

*Significance at $p \leq 0.05$

Body Mass Index

Repeated measures analysis of variance did not show a significant group by time interaction for body mass index (BMI) (TABLE II). The supplement group had an average BMI of 34 $\pm$ 2 kg/m^2 at baseline and 33 $\pm$ 2 kg/m^2 at posttest. In the placebo group, the average BMI was 33 $\pm$ 2 kg/m^2 at baseline and 32 $\pm$ 2 kg/m^2 at posttest (TABLE I). Repeated measures analysis of variance did show a significant supplement effect (TABLE II). The average BMI of the chromium group was 1 kg/m^2 higher than the average BMI for the placebo group at both baseline and posttest. Although not significant, repeated measures analysis of variance did show a trend for a significant time effect on BMI with baseline BMI being higher than posttest BMI for both groups (TABLE I).

Dietary Intake

Repeated measures analysis of variance did not show a significant group by time interaction for dietary intake (TABLE III). Repeated measures analysis of variance did show a significant time effect for kilocalorie, carbohydrate, and fiber intake (TABLE III). Mean kilocalorie, carbohydrate, and fiber intakes were higher for both groups at baseline than at posttest (TABLE IV). At baseline, kilocalorie intake was 2521 $\pm$ 224 and 2349 $\pm$ 329 for the chromium and placebo groups respectively. At posttest kilocalorie intake had decreased to 2058 $\pm$ 242 and 1763 $\pm$ 341 for the chromium and placebo groups respectively. At baseline, carbohydrate intake was 325 $\pm$ 34 g and 281 $\pm$ 34 g for the chromium and placebo groups, respectively. At posttest, carbohydrate intake decreased to

243 ± 29 g and 194 ± 33 g for the chromium and placebo groups, respectively. Fiber intake was 23 ± 2 g and 22 ± 4 g for the chromium and placebo groups at baseline respectively, then decreased to 18 ± 2 g and 14 ± 3 g for the chromium and placebo groups at posttest, respectively (TABLE IV).

Repeated measures analysis of variance also showed a significant group effect for carbohydrate intake with the chromium group having a significantly higher carbohydrate intake than the placebo group at both baseline and posttest (TABLE III). The mean carbohydrate intake for the chromium group was 325 ± 34 g and 243 ± 29 g at baseline and posttest respectively (TABLE IV). The placebo group had a mean carbohydrate intake of 281 ± 34 g at baseline and 194 ± 33 g at posttest (TABLE IV).

TABLE III

Analysis of variance summary table for kilocalorie, protein, carbohydrate, fiber, and fat intakes after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Source of Variance	Probability
Kilocalorie intake	group	0.1823
	time	0.0068*
	group*time	0.7198
Protein intake	group	0.1237
	time	0.2295
	group*time	0.7464
Carbohydrate intake	group	0.0436*
	time	0.0012*
	group*time	0.8999
Fat intake	group	0.5489
	time	0.0889
	group*time	0.8296
Fiber intake	group	0.2604
	time	0.0084*
	group*time	0.6052

*Significance at $p \leq 0.05$

TABLE IV

Mean kilocalorie, protein, carbohydrate, fiber, and fat intakes at baseline and after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Chromium group (n = 9)		Placebo group (n = 8)	
	Baseline	Posttest	Baseline	Posttest
Kilocalorie intake	2521 ± 224	2058 ± 242	2349 ± 329	1763 ± 341
Protein intake (g)	100 ± 9	93 ± 13	90 ± 13	77 ± 13
Carbohydrate intake (g)	325 ± 34	243 ± 29	281 ± 34	194 ± 33
Fat intake (g)	93 ± 9	79 ± 10	90 ± 18	72 ± 17
Fiber intake (g)	23 ± 2	18 ± 2	22 ± 4	14 ± 3

* Values are at mean ± SEM

Serum Glucose

At fasting (0 minutes) repeated measures analysis of variance showed a significant group effect with the chromium group having a significantly lower fasting glucose concentration than the placebo group at both baseline and posttest (TABLE V). The mean serum glucose concentrations at baseline were 116 ± 6 mg/dl and 119 ± 7 mg/dl for the chromium and the placebo groups respectively (TABLE VI). At posttest mean serum glucose concentrations were 117 ± 6 mg/dl and 123 ± 5 mg/dl for the chromium and placebo groups respectively (TABLE VI). Repeated measures analysis of variance also showed a significant group by time interaction for serum glucose concentrations 30 and 60 minutes after a 75 g oral glucose tolerance test (OGTT). The mean serum glucose concentration of the chromium group 30 minutes after a 75 g OGTT was 201 ± 14 mg/dl at baseline and 178 ± 14 mg/dl at posttest (TABLE VI). The placebo group had a mean serum glucose concentration of 188 ± 19 mg/dl at baseline and 211 ± 19 mg/dl at posttest 30 minutes after the OGTT (TABLE VI). For the chromium group at 60 minutes after the OGTT, the mean serum glucose was 240 ± 23 mg/dl and 214 ± 22 mg/dl, respectively (TABLE VI). At 60 minutes after the OGTT, the placebo group had a

mean serum glucose concentration of 231 ± 28 mg/dl at baseline and 241 ± 24 mg/dl at posttest (TABLE VI). Repeated measures analysis of variance also showed a trend, though not significant, for a group by time interaction for the total area under the glucose curve (TABLE V). Total area under the glucose curve for the chromium group was 811 ± 56 mg/dl at baseline and 740 ± 60 mg/dl at posttest. For the placebo group, total area under the glucose curve was 803 ± 72 mg/dl at baseline and 850 ± 71 mg/dl at posttest (TABLE VI).

TABLE V.

Analysis of variance summary table for serum glucose concentration Following a 75 g OGTT after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Source of Variance	Probability
0 minutes	group	0.0305*
	time	0.2051
	group*time	0.3698
30 minutes	group	0.3158
	time	0.9902
	group*time	0.0278*
60 minutes	group	0.2360
	time	0.2791
	group*time	0.0250*
120 minutes	group	0.2317
	time	0.8986
	group*time	0.6199
180 minutes	group	0.1005
	time	0.6006
	group*time	0.2715
Total area under glucose curve	group	0.0931
	time	0.07336
	group*time	0.0530

* Significance at $p \leq 0.05$

TABLE VI.

Mean serum glucose concentration following a 75 g OGTT at baseline and after 24 weeks of supplementation with $CrCl_3.6H_20$ or a placebo[1,2]

	Chromium group (n = 9)		Placebo group (n = 8)	
	Baseline	Posttest	Baseline	Posttest
0 minutes	116 ± 6	117 ± 6	119 ± 7	123 ± 5
30 minutes	201 ± 14	178 ± 14	188 ± 19	211 ± 19
60 minutes	240 ± 23	214 ± 22	231 ± 28	241 ± 24
120 minutes	152 ± 15	149 ± 14	160 ± 19	166 ± 20
180 minutes	101 ± 9	96 ± 13	105 ± 9	109 ± 16
Total area under glucose curve	811 ± 56	740 ± 60	803 ± 72	850 ± 71

[1]Values are given in mg/dl [2]Values are mean ± SEM

Serum Insulin

Repeated measures analysis of variance did not show a significant group by time interaction for mean serum insulin concentration in response to a 75 g OGTT (TABLE VII). There was, however, a significant group effect for mean serum insulin concentration with the chromium group having a significantly lower serum glucose concentration 30 minutes following the OGTT than the placebo group at both baseline and posttest (TABLE VII). The mean serum insulin concentration for the chromium group at 30 minutes following the 75 g glucose challenge was 12 μIU/ml lower than the placebo group at baseline, and 32 μIU/ml lower than the placobo group at posttest (TABLE VIII). Repeated measures analysis of variance showed a significant group effect for the total area under the insulin curve (TABLE VII), with the chromium group having a significantly lower area under the insulin curve than the placebo group at both baseline and posttest. The total area under the insulin curve for the chromium group was 359 ± 65 μIU/ml at baseline and 271 ± 47 μIU/ml at posttest, while the total area under the curve

for the placebo group was 375 ± 45 μIU/ml at baseline and 408 ± 69 μIU/ml at posttest (TABLE VIII).

TABLE VII.
Analysis of variance summary table for serum insulin concentration following a 75 g OGTT after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Source of Variance	Probability
0 minutes	group	0.1365
	time	0.4492
	group*time	0.3692
30 minutes	group	0.0197*
	time	0.8071
	group*time	0.2375
60 minutes	group	0.1893
	time	0.0857
	group*time	0.0673
120 minutes	group	0.0994
	time	0.7899
	group*time	0.3041
180 minutes	group	0.0799
	time	0.8220
	group*time	0.1437
Total area under insulin curve	group	0.0369*
	time	0.5990
	group*time	0.0993

* Significance at $p \leq 0.05$

TABLE VIII.

Mean serum insulin concentration following a 75 g OGTT at baseline and after 24 weeks of supplementation with $CrCl_3.6H_20$ or a placebo[1,2]

	Chromium group (n = 9)		Placebo group (n = 8)	
	Baseline	Posttest	Baseline	Posttest
0 minutes	24 ± 4	20 ± 4	26 ± 2	26 ± 5
30 minutes	78 ± 14	70 ± 12	90 ± 16	102 ± 29
60 minutes	130 ± 23	93 ± 16	124 ± 17	125 ± 27
120 minutes	85 ± 22	62 ± 8	90 ± 19	100 ± 26
180 minutes	42 ± 13	32 ± 12	45 ± 13	55 ± 26
Total area under insulin curve	359 ± 65	271 ± 47	375 ± 45	408 ± 69

[1]Values are given in μIU/ml [2]Values are mean ± SEM

Glycosylated Hemoglobin

Repeated measures analysis of variance did not show a significant group by time interaction for mean percent glycosylated hemoglobin (TABLE IX). Repeated measures analysis of variance did show a significant group effect for mean percent glycosylated hemoglobin (TABLE IX), with the chromium group having a significantly lower percent glycosylated hemoglobin at both baseline and posttest compared to the placebo group. Repeated measures analysis of variance also showed a significant time effect for mean percent glycolylated hemoglobin with both the chromium and placebo groups having significantly lower percent glycosylated hemoglobin at baseline compared to posttest. In the chromium group, the mean percent glycosylated hemoglobin levels were 5.7 ± 0.1 % at baseline and 5.8 ± 0.1 % at posttest (TABLE X). The mean percent glycosylated hemoglobin levels for the placebo group were 5.8 ± 0.1 % at baseline and 6.2 ± 0.2 % at posttest (TABLE X).

TABLE IX.

Analysis of variance summary table for percent glycosylated hemoglobin and percent specific insulin binding after 24 weeks supplementation with $CrCl_3.6H_20$ or a placebo*

	Source of Variance	Probability
Glycosylated Hemoglobin	group	0.0224*
	time	0.0092*
	group*time	0.1329
Percent Specific Insulin Binding (per 100 μg protein)	group	0.4445
	time	0.0579
	group*time	0.6808

* Significance at $p \leq 0.05$

TABLE X.

Mean percent glycosylated hemoglobin and percent specific insulin binding at baseline and after 24 weeks of supplementation with $CrCl_3.6H_20$ or a placebo*

	Chromium group (n = 9)		Placebo group (n = 8)	
	Baseline	Posttest	Baseline	Posttest
Glycosylated Hemoglobin (%)	5.7 ± 0.1	5.9 ± 0.1	5.8 ± 0.1	6.2 ± 0.2
Specific Insulin Binding (%) (per 100 μg protein)	3.0 ± 0.4	2.4 ± 0.2	3.4 ± 0.2	2.6 ± 0.1

* Values are at mean ± SEM

Percent Specific Insulin Binding

For mean percent specific insulin binding, repeated measures analysis of variance did not show a significant time by group interaction (TABLE IX). There was a trend for a significant time effect with percent specific insulin binding tending to decrease from baseline to posttest for both groups (TABLE IX). The mean percent specific insulin binding per 100 μg protein for the supplement group was 3.0 ± 0.4 % at baseline, and 2.4

$\pm$ 0.2 % at posttest (TABLE X). In the placebo group, the percent specific insulin binding per 100 µg protein was 3.4 $\pm$ 0.2 % at baseline and 2.6 $\pm$ 0.1 % at posttest.

Discussion

Weight and Body Mass Index

No significant time by group interaction was observed in the current study for weight or body mass index. This was a desired observation, since the participants were instructed not to change their dietary or exercise habits for the duration of the study.

Dietary Intake

A significant time effect was observed for kilocalorie, carbohydrate, and fiber intake with kilocalories, carbohydrate and fiber intakes significantly decreasing in both groups from baseline to posttest. This was not a desirable observation because the participants were instructed not to change their dietary habits for the duration of the study. The dietary data were, however, self-reported.

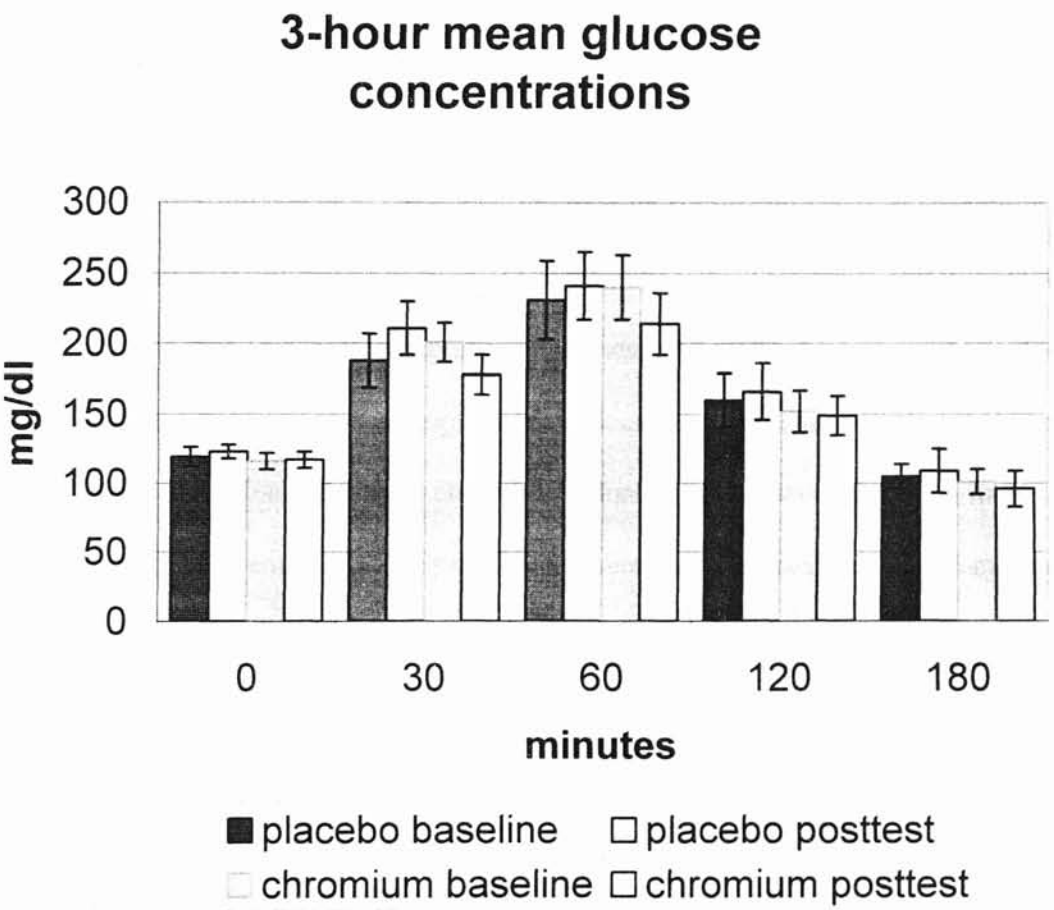
Serum Glucose

Ho_1: There will be no statistically significant effect of 24 weeks supplementation with 200 µg chromium per day, as chromium chloride, on 3-hour glucose curves following a 75 g oral glucose load among glucose intolerant men.

Although not significant, there was a trend in the current study for a group by time interaction for total area under the glucose curve, with the chromium group tending to have a significant decrease in the total area under the glucose curve from baseline to

posttest compared to the placebo group. A significant group by time interaction was observed for serum glucose concentration at 30 and 60 minutes following an OGTT, with serum glucose concentration significantly decreasing from baseline to posttest 30 and 60 minutes following an OGTT in the chromium group compared to the placebo. Since significant results were found, the researchers reject the null hypothesis.

FIGURE I



These observations are similar to those reported in other studies. A study by Anderson et al. also reported a significant decrease in serum glucose concentrations with chromium supplementation when compared to a placebo. Participants were given 19.2

μmol chromium as chromium picolinate per day for four months. The participants in this study were diagnosed with type 2 diabetes, and fasting and 2-hour serum glucose concentrations were higher at baseline than the fasting and 2-hour serum glucose concentrations in the current study (Anderson et al., 1997).

In a case study by Fox and Sabovic, a woman with type 1 diabetes self reported a decrease in blood glucose concentrations after supplementation with 600 μg chromium as chromium picolinate for three months. The level of chromium supplementation in the case study reported by Fox and Sabovic was three times the amount given to participants in the current study (Fox and Sabovic, 1998).

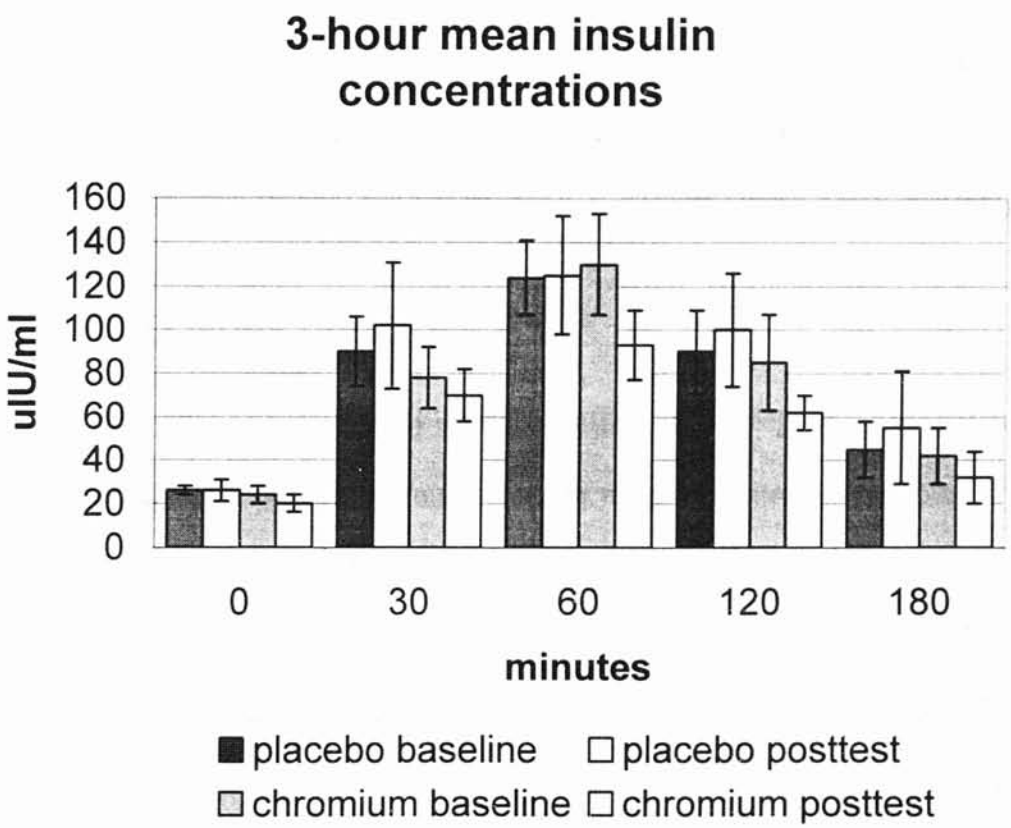
A study by Abraham et al.; however, reported no significant effect of chromium supplementation on fasting serum glucose concentrations (Abraham et al., 1992). In this study, seventy-six participants (the majority being men; some diabetic and some healthy) were randomly assigned to either a supplement or placebo group. The supplement group received 250 μg chromium per day as chromium chloride, which was only 50 μg more chromium than the current study. The participants were supplemented for 7 to 16 months (Abraham et al., 1992).

Serum Insulin

Ho_2: There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on 3 hour insulin curves following a 75 g oral glucose load among glucose intolerant men.

Repeated measures analysis of variance did not show a significant group by time interaction for any point in the insulin curve, therefore the researcher fails to reject the null hypothesis.

FIGURE II



These results are similar to those reported by Martinez et al. Martinez et al. reported no significant effect on serum insulin concentrations as a result of 10 weeks chromium supplementation (Martinez et al., 1985). Eighty-five women, ages 59 to 82, who were either healthy or who were considered to be "at risk" for glucose intolerance by study standards, participated in the research. Participants were randomly assigned to either a chromium supplement group, which received 200 μg chromium per day as

chromium chloride in a vial of water, or a placebo group, which received a vial of plain water (Martinez et al., 1985).

Anderson et al. did report a significant effect on serum insulin concentration after 2 and 4 months chromium supplementation compared to placebo for participants who received 3.85 μmol chromium per day as chromium picolinate (Anderson et al., 1997). The participants in this study differed from the participants in the current study in that they had been diagnosed with type 2 diabetes, and were a mixed group of men and women with no separation given to pre or post menopausal state (Anderson et al., 1997).

Glycosylated Hemoglobin

H_{03}: There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on glycosylated hemoglobin concentration among glucose intolerant men.

Repeated measures analysis of variance did not show a significant group by time interaction for glycosylated hemoglobin, therefore the researcher fails to reject the null hypothesis. Glycosylated hemoglobin, which is used as a long-term indicator of glucose tolerance, is between 4% and 8% in individuals without diabetes (Lee and Nieman, 2000). Percent glycosylated hemoglobin in the current study fell within the 4% to 8% range at both baseline and posttest. Since the observed values were in the normal range to begin with, a change would not be expected as a result of chromium supplementation.

Percent Specific Insulin Binding

H_{o4}: There will be no statistically significant effect of 24 weeks supplementation with 200 μg chromium per day, as chromium chloride, on percent specific insulin binding among glucose intolerant men.

Repeated measures analysis of variance did not show a significant group by time interaction for mean percent specific insulin binding, therefore the researcher fails to reject the null hypothesis. Bhathena et al. reported a percent specific insulin binding per 100 μg protein of 2.51% for healthy individuals (Bhathena et al., 1995). This value is similar to the percent specific insulin binding observed in the current study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study investigated the effects of 24 weeks of 200 μg chromium supplementation per day as chromium chloride on glucose intolerance in men. Twenty men with glucose intolerance were matched to one of two groups. The groups were then randomly assigned to receive either a chromium supplement, which contained 200 μg chromium as chromium chloride, or a lactose placebo for 24 weeks. Measurements on three-hour serum glucose curves, three-hour serum insulin curves, percent glycosylated hemoglobin concentrations, and percent specific insulin binding were conducted at baseline and after 24 weeks supplementation. Three participants were excluded from final data analysis due to non-compliance or failure to arrive at the final data collection. As a result, 9 participants were in the chromium group, and 8 participants were in the placebo group for final data analysis. Repeated measures analysis of variance showed a significant group by time interaction in three-hour serum glucose concentrations at 30 and 60 minutes following a 75 g oral glucose challenge. Repeated measures analysis of variance did not show a significant group by time interaction for three-hour serum insulin concentrations, glycosylated hemoglobin concentrations, or percent specific insulin binding after 24 weeks supplementation.

Conclusions

In conclusion, the results of this study indicate a trend for chromium having a beneficial effect on glucose and insulin concentrations in men with glucose intolerance. However, with the new AI for chromium being so much lower than the previous ESADDI, further research is needed investigating effects of chromium supplementation at lower levels of chromium intake.

Recommendations

A crossover experimental design may have been beneficial due to the small sample size. A crossover design would have increased the number of participants receiving the chromium supplements.

Meeting individually with the participants during the study might have helped to ensure compliance. Simply delivering the supplements to the participants personally each month may not have been enough contact to encourage full compliance.

Having a trained researcher such as a health care provider or a dietetic intern complete the food frequency questionnaire one-on-one with each participant, instead of the participants completing the questionnaire on their own may improve food frequency records.

Fructosamine, which is a test for glucose control, might be helpful to run in this type of research. Fructoseamine is a longer term-test indicator of glucose control than serum glucose concentration, but it is a shorter-term indicator than glycosylated

hemoglobin. This test might better reflect the impact of chromium supplementation in studies done for a length of time similar to that in the current study.

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APPENDICES

APPENDIX A

APPROVAL FORMS FOR INSTITUTIONAL REVIEW BOARD FOR HUMAN PARTICIPANT RESEARCH

DEC 13 1999

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

DATE: 02-09-99 **IRB #: HE-99-058**

Proposal Title: EFFECTS AND INTERACTIONS OF CHROMIUM AND COPPER SUPPLEMENTATION ON INDICATORS OF DIABETES IN PREDIABETIC MEN WITH HYPERINSULINEMIA

Principal Investigator(s): Janice R. Hermann

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

Signature: Carol Olson Date: February 10, 1999

Carol Olson, Director of University Research Compliance

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	December 9, 1999	IRB #: HE-99-058
Proposal Title:	"EFFECTS AND INTERACTIONS OF CHROMIUM AND COPPER SUPPLEMENTATION ON INDICATORS OF DIABETES IN PREDIABETIC MEN WITH HYPERINSULINEMIA"	
Principal Investigator(s):	Janice Hermann	
Reviewed and Processed as:	Continuation	

Approval Status Recommended by Reviewer(s) Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

December 9, 1999
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	January 31, 2000	IRB #:	HE-99-058

Proposal Title: "EFFECTS AND INTERACTIONS OF CHROMIUM AND COPPER SUPPLEMENTATION ON INDICATORS OF DIABETES IN PREDIABETIC MEN WITH HYPERINSULINEMIA"

Principal Investigator(s): Janice Hermann

Reviewed and Processed as: Modification

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

January 31, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

APPENDIX B

RECRUITMENT ANNOUNCEMENTS

ARE YOU AT RISK FOR DEVELOPING DIABETES ?

Male Participants Wanted Who Are At Risk For Diabetes

Did you know that low intake of certain minerals may increase your risk of developing diabetes?

Would you like to know if an adequate mineral intake lowers your risk of developing diabetes?

You may be at risk of developing diabetes if you have one or more of the following:

- Over 40 years of age
- Overweight
- Family history of diabetes

Volunteers who meet the study criteria will receive $300 for completing the study.

For further information about the men's diabetes study please contact:

Janice R Hermann, PhD, RD/LD
Department of Nutritional Sciences
Oklahoma State University
Stillwater, Oklahoma 74078
(405) XXX-XXX

APPENDIX C

NEWSPAPER RECRUITMENT ADD

Men at risk for diabetes wanted for OSU nutrition study. Factors increasing risk of diabetes include family history of diabetes, overweight, over 40 years of age. Men meeting the study criteria will receive $300 for completing the study. Call XXX-XXX.

APPENDIX D

INFORMED CONSENT FORM TO PARTICIPATE IN SCREENING

INFORMED CONSENT FOR MEN'S DIABETES STUDY SCREENING
Effect of Chromium Supplementation on Indicators of Diabetes in Men at Risk for Diabetes

"I,_____, hereby volunteer to participate in the screening for the above titled study and authorize or direct Janice R. Hermann, Ph.D., R.D./L.D., or associates of her choosing, to perform the following treatment or procedure."

I understand that:

(1) this is a screening for fasting and 2 hour glucose as criteria for participating in the above titled study on indicators of diabetes in men at risk for diabetes;

(2) I will have my finger pricked with a finger-lancing device by trained personnel to obtain a drop of blood from which my fasting whole blood glucose will be measured using a HemoCue instrument.

(3) If my fasting whole blood glucose measured with the HemoCue is below 126 mg/dL, a licensed phlebotomist will draw a fasting blood sample of 6-ml by venipuncture. After which I will consume a glucose drink containing 75-g glucose. I will have a 6-ml blood sample drawn by venipuncture by a licensed phlebotomist 120 minutes after consuming the glucose drink.

(4) I may have slight discomfort and/or bruising from the venipuncture;

(5) after the two-hour blood sample I will receive a light meal for nutritional support;

(6) my blood will only be used for the study protocol, and any remaining blood will be discarded and no further tests will be run;

(7) I will complete a Health Questionnaire concerning health conditions, medication use, vitamin and mineral supplement use and exercise practices;

(8) I will have my height and weight measured;

(9) all my records are confidential and my name will not be associated with any reports;

(10) I will receive a form with my personal fasting and two-hour serum glucose concentrations with accepted ranges for each laboratory value. There will be a statement at the bottom of the form indicating that I should see a physician if my personal laboratory results are not in the accepted ranges.

(11) my participation in the screening is voluntary, that there is no penalty for refusal to participate;

(12) I will be notified by the project director if I meet the criteria to participate in the study;

(13) meeting the criteria for the study does not mean I am committed to participate in the study, my participation in the study is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying the project director;

(14) this research is beneficial to the public in that the risk of diabetes increases with age and low mineral intake.

(15) I may contact Dr Janice Hermann at (405) 269-1002 should I wish further information. I may also contact Sharon Bacher, IRB Executive Secretary, 203 Whitehurst, Oklahoma State University, Stillwater, OK 74078; telephone (405) 744-6244.

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date_____ Time_____(a.m./p.m.)

Signed_____
Signature of Subject

I certify that I have personally explained all elements of this form to the subject before requesting the subject to sign it.

Signed _____
(project director or her authorized representative)

APPENDIX E

HEALTH QUESTIONNAIRE

HEALTH QUESTIONNAIRE

Screening Code _____

Date of Birth _____

Do you have or have you ever been told you had any of the following conditions?

onditions	NO	YES	Specify
iabetes			
mily history of abetes			
gh blood pressure			
gh triglycerides			
art disease			
ıer health nments			

Do you currently take any medications on a regular basis? No _____ Yes _____

Specify all medications taken on a regular basis:

ne _____ How often _____ per day Or _____ per week

ne _____ How often _____ per day Or _____ per week

ne _____ How often _____ per day Or _____ per week

ıe _____ How often _____ per day Or _____ per week

ıe _____ How often _____ per day Or _____ per week

)o you exercise on a regular basis? No _____ Yes _____

low many times a week do you regularly exercise?_____

low many minutes would you estimate you regularly exercise in a week?_____

BE COMPLETED BY RESEARCH STAFF

ing Glucose _____ **mg/dL Two-Hour Glucose** _____ **mg/dL**

APPENDIX F

GLUCOSE TOLERANCE BEVERAGE

CAUTION: Federal law (U.S.A.) prohibits dispensing without a prescription.

Active Ingredient: 10.0 g glucose per fl. oz. (29.6 mL). Contains carbonated water, dextrose (d-glucose, source: corn), natural flavoring, citric acid, sodium benzoate, FD&C Yellow No. 6 (Sunset Yellow) as a color additive.

Indications and Usage: Trutol® 100 is indicated for the detection of glucose intolerance in the evaluation of gestational diabetes mellitus. For oral consumption only.

Precautions: Pregnant or nursing women and persons having diabetes take Trutol® 100 only under the direction of a physician.

Adverse Reactions: The most common adverse reactions to Trutol® 100 are nausea, vomiting, abdominal bloating and/or headache.

Dosage and Administration: The recommended usual dosage is 10.0 oz. (100g dextrose) for pregnant women. Instruct the patient to remain quiet, refrain from smoking and from drinking beverages containing caffeine just before and during the test. Start timing when the patient begins to drink Trutol® 100 (drink in about 5 min.). Obtain blood sample 1 hr. later. To enhance palatability, chill before serving. Protect from light. Do not freeze. Discard unused contents.

Reference: For further details on the test and its interpretation, see: *Summary and Recommendations of the Second International Workshop—Conference on Gestational Diabetes Mellitus*, 34 (2) DIABETES 123, June 1985.

GLUCOSE TOLERANCE BEVERAGE • GLUCOSE TOLERANCE BEVERAGE • GLUCOSE TOLERANCE BEVERAGE • GLUCOSE TOLERANCE BEVERAGE •

APPENDIX G

INFORMED CONSENT FORM TO PARTICIPATE IN RESEARCH

Men's Diabetes Study: Effect of Chromium Supplementation
on Indicators of Diabetes in Men at Risk for Diabetes

"I,_____, hereby volunteer to participate in the above titled study and authorize or direct Janice R. Hermann, Ph.D., R.D./L.D., or associates or assistants of her choosing, to perform the following treatment or procedure."

I understand that:

(1) the purpose of the study is the measure the effect of chromium supplementation on indicators of diabetes in prediabetic men with elevated insulin;

(2) I will receive one month's of supplements containing ONE of the following:

(a) a placebo
(b) 200 ug chromium

(3) I will take one supplement a day with a meal for 24 weeks;

(4) I will not take any other vitamin/mineral supplements or herbal/dietary supplements that contain chromium other than those that are part of this study;

(5) I will return each month to receive the next month's supplements.

(6) I will participate in a fasting blood collection and 3-hour glucose tolerance test at the beginning of the study, after 12 weeks supplementation and after 24 weeks supplementation. A licensed phlebotomist will draw a fasting blood sample of 20 ml by venipuncture. After which I will consume a glucose drink containing 75-g glucose. I will have a 6 ml blood sample drawn by venipuncture by a licensed phlebotomist 30, 60, 120, and 180 minutes after consuming the glucose drink.

(7) I may have slight discomfort and/or bruising from the venipuncture.

(8) after the 3-hour glucose tolerance test I will receive a light lunch for nutritional support.

(9) my blood will only be used for the study protocol, and any remaining blood tissue will be discarded and no further tests will be run.

(10) routine measurements of my body weight will be taken at the beginning of the study, after 12 weeks supplementation and after 24 weeks supplementation;

(11) I will complete a Health Questionnaire concerning health conditions, medication use, vitamin and mineral supplement use and exercise practices at the beginning of the study, and a Follow-up Health Questionnaire after 12 weeks supplementation and after 24 weeks supplementation;

(12) I will complete a 1-week food frequency questionnaire at the beginning of the study, after 12 weeks supplementation, and after 24 weeks supplementation;

(13) as a reward for participation and as an incentive to complete the study, I will receive $150 after completing each of the three data collections for a total of $450; $150 after the data collection at the beginning of the study, $150 after the data collection after 12 weeks supplementation, and $150 after the data collection after 24 weeks supplementation.

(14) all my records are confidential and that my name will not be associated with any reports or data records at the end of the study;

(15) I will receive a form with my personal laboratory results with accepted ranges for each laboratory value. There will be a statement at the bottom of the form indicating that I should see a physician if my personal laboratory results are not in the accepted ranges.

(16) my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying the project director;

(17) I will withdraw from the project if I need to begin taking medication for diabetes during this study;

(18) this research is beneficial to the public in that the risk diabetes increasing with age and low mineral intake.

(19) I may contact Dr Janice Hermann at (405) 269-1002 should I wish further information. I may also contact Sharon Bacher, IRB Executive Secretary, 203 Whitehurst, Oklahoma State University, Stillwater, OK 74078; telephone (405) 744-6244..

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date_____ Time_____(a.m./p.m.)

Signed_____
Signature of Subject

I certify that I have personally explained all elements of this form to the subject before requesting the subject to sign it.

Signed _____
(project director or her authorized representative)

APPENDIX H

FOOD FREQUENCY QUESTIONNAIRE

Code Number_____

Men's Diabetes Study
Seven Day Food Frequency Questionnaire

This questionnaire asks you about your consumption of foods and beverages over the past week. The "How Often" columns are for day, week, or rarely/never. We want you to think back over the past week and tell us how many times (per day or per week) you consumed each item. A medium serving is in parentheses.

EXAMPLES:

Ate 1/2 grapefruit about twice last week.
Ate 1 large hamburger four times last week.
Drank 2 cups of whole milk each day.

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
Grapefruit (1/2)		2			X	
Hamburger, regular (1 patty, 3 oz)		4				X
Whole milk (1 cup, 8 oz)	2				X	

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
DAIRY FOODS						
Whole milk (1 cup, 8 oz)						
2% milk (1cup, 8 oz)						
1% milk (1 cup, 8 oz)						
Skim milk (1 cup, 8 oz)						
Rice milk (1 cup, 8 oz)						
Soy milk (1 cup, 8 oz)						
Milk Shake (16 oz)						
Pudding (1/2 cup)						
Cream, whipped (1 Tbsp)						
Sour cream (1 Tbsp)						
Coffee cream (1 Tbsp)						
Ice cream (½ cup)						
Low fat ice cream (½ cup)						
Frozen yogurt (½ cup)						
Yogurt (1 cup)						
Low fat yogurt (1 cup)						
Cottage cheese (½ cup)						
Cream cheese (1 oz)						
Low fat cream cheese (1 oz)						
Other cheese (1 slice or 1 oz)						
Low fat cheese (1 slice or 1 oz)						
Margarine (1 tsp)						
Butter (1 tsp)						
Reduced fat margarine (1 tsp)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
FRUITS, FRUIT JUICES						
Raisins (1 oz or 1 sm box)						
Grapes (20)						
Prunes (½ cup)						
Bananas						
Cantaloupe (¼ melon)						
Watermelon (1 slice)						
Apples, applesauce or pears (1 fresh, ½ cup)						
Apple juice (½ cup)						
Oranges						
Orange juice (½ cup)						
Grapefruit (½ cup)						
Grapefruit juice (½ cup)						
Cranberry juice (½ cup)						
Other fruit juices (½ cup)						
Strawberries—fresh, frozen, or canned (½ cup)						
Blueberries—fresh, frozen, or canned (½ cup)						
Peaches (1 fresh, ½ cup canned)						
Apricots (1 fresh, ½ cup canned)						
Plums (1 fresh, ½ cup canned)						
Honeydew melon (¼ melon)						
Kiwi (1 medium)						
Fruit Cocktail (½ cup)						
Mango (½ cup, or ½ small)						
Raspberries (½ cup)						
Blackberries (½ cup)						
Dried fruit (1/4 cup)						
Pears (1 medium)						
Pineapple chunks (½ cup)						
Lemon juice (1/4 cup)						
Lime juice (1/4 cup)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
VEGETABLES, VEGETABLE JUICE						
Tomatoes (1)						
Tomato juice (½ cup)						
Tomato sauce (½ cup)						
Spaghetti sauce (½ cup)						
Red chili sauce, taco sauce, or salsa (1 Tbsp)						
Tofu or soybeans (3-4 oz)						
String beans, green beans (½ cup)						
Broccoli (½ cup)						
Cabbage (½ cup)						
Cole slaw (½ cup)						
Cauliflower (½ cup)						
Brussels sprouts (½ cup)						
Carrots, raw (½ carrot or 2-4 sticks)						
Carrots, cooked (½ cup)						
Corn (1 ear or ½ cup frozen or canned)						
Peas (½ cup fresh, frozen or canned)						
Lima beans (½ cup frozen, or canned)						
Mixed vegetables (½ cup)						
Beans or lentils, baked or dried (½ cup)						
Summer or yellow squash (½cup)						
Winter squash (½ cup)						
Zucchini (½ cup)						
Yam or sweet potato (½ cup)						
Spinach, (cooked ½ cup, raw 1 cup)						
Iceberg lettuce, romaine or leaf (1 cup)						
Celery (4" stick)						
Beets (½ cup)						
Alfalfa sprouts (½ cup)						
Kale, mustard, or chard greens (½ cup)						
Vegetable, vegetable beef, minestrone or tomato soup (1 cup)						
Okra (½ cup)						
Cucumber slices (½ cup)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
VEGETABLES, VEGETABLE JUICE (Cont.)						
Mushrooms (½ cup)						
Collard greens (½ cup)						
Turnip greens (½ cup)						
Onion (½ cup)						
Pickles (½ cup)						
Sweet peppers (½ cup)						
Asparagus (½ cup)						
Jalapeno peppers (1/4 cup)						
Potato salad (½ cup)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
EGGS, MEAT, ECT.						
Eggs (2)						
Chicken or turkey, roasted or broiled with skin (3-4 oz)						
Chicken or turkey, roasted or broiled skinless (3-4 oz)						
Chicken, fried with skin (3-4 oz)						
Bacon (2 slices)						
Hot dogs (2)						
Low fat hot dogs (2)						
Sausage (2 patties or 2 links)						
Bologna (1 slice)						
Other processed luncheon meat (1 slice)						
Liver, chicken or beef (3-4 oz)						
Hamburger, regular (1 patty, 3-4 oz)						
Hamburger, lean (1 patty, 3-4 oz)						
Meat loaf (3-4 oz)						
Pork, chops, roasts (3-4 oz)						
Lamb (3-4 oz)						
Beef, roast, steak (3-4 oz)						
Beef stew with vegetables (1 cup)						
Ham (3-4 oz)						
Tuna (3-4 oz)						
Tuna salad (½ cup)						
Fish, baked or broiled (3-4 oz)						
Fish, fried or fish sandwich (3-4 oz)						
Shrimp, Lobster, Scallops						
Pizza (2 slices)						
Mixed dishes with cheese (1 cup)						
Lasagna or meat pasta dishes (1 cup)						
Pot pie (1 each)						
Egg beaters (½ cup)						
Pork ribs (3 ribs)						
Deli meats (3 oz)						
Ground turkey (3 oz)						
Chicken salad (½ cup)						
Chili (1 cup)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
BREADS, CEREALS, STARCHES						
Cold breakfast cereal (1 cup)						
Cold breakfast cereal—fortified (1 cup)						
Cooked oatmeal (1 cup)						
Other cooked breakfast cereal (1 cup)						
White bread (1 slice)						
Pita bread (1 piece)						
Dark bread (1 slice)						
English muffin (1)						
Bagel (1)						
Dinner roll (1)						
Hamburger or hotdog bun (1)						
Muffin (1)						
Biscuit (1)						
Corn bread, corn muffin (1)						
Brown rice (1cup)						
White rice (1cup)						
Spaghetti noodles (1 cup)						
Macaroni noodles (1 cup)						
Other pasta noodles (1 cup)						
Bulgar, kasha, couscous (1 cup)						
Pancakes or waffles (2)						
Potatoes, french fries or fried (½ cup)						
Potatoes, baked or boiled (1)						
Mashed potatoes (1 cup)						
Potato chips or corn chips (small bag or 1 oz)						
Saltine crackers (5)						
Saltine crackers, low sodium (5)						
Saltine crackers, fat free (5)						
Other crackers (5)						
Other crackers, low fat (5)						
Tortilla (1 medium)						
Graham cracker (3 medium)						
Pretzels (15 small)						
Trail mix (1 cup)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
BEVERAGES						
Regular soft drink (1)						
Diet soft drink (1)						
Caffeine free soft drink (1)						
Caffeine free, Diet soft drink (1)						
Lemonade or other non-carbonated drink (1 glass, bottle, or can)						
Coffee (1 cup)						
Decaffeinated coffee (1 cup)						
Tea (1 cup)						
Herbal tea (1 cup)						
Beer (1 glass, bottle, or can)						
Red wine (4 oz glass)						
Pink wine (4 oz glass)						
White wine (4 oz glass)						
Whiskey, gin, or other liquor (1 drink or shot)						

Type of Food (Medium Serving)	How Often			Size		
	Day	Week	Rarely/ Never	S	M	L
SWEETS, BAKED GOODS, MISC.						
Sorbet (½ cup)						
Granola bar (1 small bar)						
Chocolate (1 small bar or 1 oz)						
Candy bar (1 small bar)						
Candy without chocolate (1 oz)						
Cookies, home baked (2)						
Cookies, ready made (2)						
Brownies (2)						
Doughnuts (2)						
Cake, home baked (1 slice)						
Cake, ready made (1 slice)						
Sweet roll, coffee cake, or other pastry ready made (1 serving)						
Sweet roll, coffee cake, or other pastry home baked (1 serving)						
Pie, homemade (1 slice)						
Pie, ready made (1 slice)						
Jam, jelly, preserves, syrup, or Honey (1 Tbsp)						
Peanut butter (1 Tbsp)						
Popcorn (1 cup)						
Popcorn, air popped (1 cup)						
Nuts (small packet or 1 oz)						
Bran, added to food (1 Tbsp)						
Wheat germ (1 Tbsp)						
Chowder or cream soup (1 cup)						
Oil and vinegar dressing (1 Tbsp)						
Soy sauce (1 tsp)						
Mayonnaise or other creamy salad dressing (1 Tbsp)						
Mustard, dry or prepared (1 tsp)						
Salt (1 shake)						
Pepper (1 shake)						

VITA 2

Rachael Mary Belvin Condley

Candidate for the Degree of

MASTER OF SCIENCE

Thesis: THE EFFECTS OF 24 WEEKS OF CHROMIUM SUPPLEMENTATION ON GLUCOSE INTOLERANCE IN MEN

Major Field: Nutritional Sciences

Biographical:

Personal Data: Born in Perryton, Texas, on October 29, 1977, the daughter of Jim and Leanor K. Belvin.

Education: Attended Oklahoma State University in Stillwater, Oklahoma from August, 1996 to May, 2002. Received a Bachelor of Science degree in Nutritional Sciences in May, 2000 with an emphasis in Dietetics, and completed the requirements for the Master of Science degree with a major in Nutritional Sciences in May, 2002.

Professional Experience: Undergraduate Laboratory Assistant for Dr. Andrea Arquitt in the Nutritional Sciences Department at Oklahoma State University, September 1996 to May 1997. Undergraduate Laboratory and Research Assistant for Dr. Janice Hermann in the Nutritional Sciences Department at Oklahoma State University, August 1997 to May 2000. Graduate Research Assistant for Dr. Janice Hermann in the Nutritional Sciences Department at Oklahoma State University, May 2000 to May 2002. Graduate Teaching Assistant for Dr. Andrea Arquitt in the Nutritional Sciences Department at Oklahoma State University, August 2001 to December 2001.