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The Effects of Chromium Picolinate Supplementation on Body Fat, Lean Body Mass, and Respiratory Exchange Ratio

Matthew K. Beaty
Western Michigan University

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THE EFFECTS OF CHROMIUM PICOLINATE SUPPLEMENTATION ON BODY FAT, LEAN BODY MASS, AND RESPIRATORY EXCHANGE RATIO

by

Matthew K. Beaty

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education, and Recreation

Western Michigan University
Kalamazoo, Michigan
April 1996
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Sincere appreciation is extended to the members of my advisory committee, Dr. Roger Zabik, Dr. Mary Dawson, and Dr. Patricia Frye. Thank you for your efforts and guidance when I had no direction, keeping me sane during data collection, and the countless times you read, re-read, and edited my thesis.

I would like to acknowledge David Paschke for his assistance in obtaining the chromium and supplies required during data collection. I am most indebted to the subjects who consented to be studied and the volunteers who helped test them. I would also like to thank my mentor, Dr. David Martin, my exercise physiology professor at the University of Wyoming, for sharing his wisdom and passion in the field of exercise physiology with me.

Finally, thanks to my parents and family for their love, support, and understanding. Thank you, Mom and Dad, for encouraging me to do my best, but most of all for encouraging me to be myself.

Matthew K. Beaty
The purpose of this study was to investigate the effects, on college-age males, of ingesting chromium picolinate over a 6-week period when administered as a supplement to their diet. Fifty males, ages 18 to 25 years, had their respiratory exchange ratio (R), body fat percentage, and lean body mass measured prior to and following a 6-week supplementation period. Subjects were randomly placed into a chromium, placebo, or control group. All subjects were instructed to maintain daily activities. Analysis of variance revealed no significant differences in R values, body fat percentage, or lean body mass among the chromium, placebo, or control groups. These findings showed that chromium picolinate supplementation did not significantly influence the metabolism of college-age males over a 6-week period.
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CHAPTER I

INTRODUCTION

Dietary supplementation is becoming more common in today’s society, and there are many conflicting opinions concerning which supplements should be taken. The recommended dosage for chromium is 50 to 200 µg daily as established by the National Academy of Sciences. It was found that approximately 90% of American diets were below the lowest recommended levels (Anderson & Kozlovsky, 1985). Diets designed by 22 United States Department of Agriculture (USDA) nutritionists averaged only 15 µg per 1,000 calories (Anderson, 1992). Modern food processing techniques add to this problem by removing up to 80% of the chromium in most cereals, grains, and sugars (Pi-Sunyer & Offenbacher, 1984). In addition, consumption of high-sugar diets increases chromium excretion by 10% to 300% (Kozlovsky, Moser, Reiser, & Anderson, 1986).

Chromium picolinate has been reported to increase muscle and reduce fat in athletes as well as in sedentary individuals. Chromium is an essential insulin cofactor. A deficiency in chromium affects the insulin sensitivity of the cells, which in turn slows the burning of food for energy. If the food we consume is not being used for fuel, the body then converts it to fat.

Insulin works in an anabolic manner on the essential amino acids used in building muscle tissue. Once inside the cell, the amino acids are assembled to repair the exercised
muscle.

Statement of the Problem

The problem of the study was to investigate the effects, on college age males (ages 18 to 25 years), of ingesting chromium picolinate over a 6-week period when administered as a supplement to their diet. Respiratory exchange ratio (R) (at a submaximal state), body fat percentage, and lean body mass were measured to determine whether a shift in substrate utilization, reduction in percentage of body fat, or an increase in lean body mass occurred over the 6-week period.

Significance of the Study

Chromium picolinate is currently being used by a wide variety of individuals from diabetics to body builders to help regulate blood sugar, reduce body fat, increase muscle mass, and provide a variety of other outcomes. If both the reductions in body fat and increases in lean body mass attributed to chromium supplementation occur, then substrate utilization can be more accurately pin-pointed as the cause for these effects. Because chromium picolinate has been on the market as a supplement for less than a decade, much of the research to date has been on its effects, rather than on why these effects occur. This study could provide support for the premise that chromium supplementation changes substrate utilization.
Delimitations

The study was delimited to the following:

1. Subjects were male college students, aged 18 to 25 years ($N = 50$).

2. Subjects were free from any blood glucose regulatory problems or diseases, such as hypoglycemia or diabetes.

3. Subjects were randomly assigned to one of three groups as follows: (1) chromium supplementation group, (2) placebo group, and (3) control group.

4. Subjects continued their daily activities as usual, including aerobic and anaerobic training or lack thereof.

5. Body composition and R levels were measured before and after a 6-week supplementation period.

6. Body composition was measured by hydrostatic weighing.

7. R levels were measured using a Quinton metabolic cart with subjects in a fasted state.

8. Subjects walked on the treadmill until R levels reached a steady state.

Limitations

The study was limited by the following:

1. Daily activities of subjects were not controlled.

2. The investigator was unable to personally conduct all of the hydrostatic and R testing both before and after supplementation.
3. The investigator could not control whether the subjects maintained their normal diet during the supplementation period.

4. The investigator could not control whether the subjects were taking other supplements that could produce the same or opposite effects.

5. Chromium levels could differ with each subject prior to supplementation.

6. Supplementation of 200 µg of chromium picolinate could affect each subject differently.

Assumptions

The study was conducted under the following assumptions:

1. Subjects' diet and exercise levels were maintained.

2. Subjects took the supplement or placebo on a daily basis.

3. Instruments calibrated according to manufacturer recommendations produced accurate results.

Research Hypotheses

The researcher hypothesized that:

1. The supplementation group experienced a greater reduction in the R level than the placebo group or the control group.

2. The supplementation group experienced a greater reduction in body fat percentage than the placebo group or the control group.

3. The supplementation group experienced a greater increase in lean body mass
than the placebo group or the control group.

4. The placebo group experienced a greater reduction in the R level than the control group.

5. The placebo group experienced a greater reduction in body fat percentage than the control group.

6. The placebo group experienced a greater increase in lean body mass than the control group.

Definition of Terms

For consistency of interpretation, the following terms were defined:

1. Anabolism. Energy-requiring, building phase of metabolism in which simpler substances are combined to form more complex substances (Marieb, 1992).


3. Glucose. A simple sugar that is transported via the blood and metabolized by tissues (Powers & Howley, 1994).


5. Glycogen. A polymer of glucose; the form in which glucose is stored in the body, mainly in muscles and the liver (Fox, Bowers, & Foss, 1989).

6. Hypoglycemia. A decrease in the blood glucose concentration to below normal levels (Rhoades & Pflanzer, 1992).

7. Lipase. An enzyme responsible for the breakdown of triglycerides to free fatty
acids and glycerol (Powers & Howley, 1994).

8. Lipolysis. The breakdown of triglycerides in adipose tissue to free fatty acids and glycerol for subsequent transport to tissues for metabolism (Powers & Howley, 1994).

9. Respiratory exchange ratio (R). The ratio of CO$_2$ production to O$_2$ consumption. R values are indicative of substrate utilization during steady state exercise; a value of 1.0 represents 100% carbohydrate metabolism, and 0.7 represents 100% fat metabolism (Powers & Howley, 1994).

10. Somatomedin. A growth factor found in many tissues, including the liver, that mediates the effect of growth hormone on cartilage (Rhoades & Pflanzer, 1992).
CHAPTER II

REVIEW OF LITERATURE

History

Development

In 1969, Mertz postulated that the physiological effects of chromium were mediated by an organic chromium complex, glucose tolerance factor (GTF), which was produced in the body, but also absorbed efficiently from certain foods such as brewer's yeast (McCarty, 1991). Researchers in the past 25 years have failed to confirm the structure of, or verify the existence of, a GTF produced by the body as suggested by Mertz. A crystalline preparation of GTF has never been achieved, and presently there is no convincing evidence that the body makes a specific organic chromium complex that mediates chromium's actions. Over a decade ago, USDA scientists under the direction of Dr. Gary Evans developed chromium tripicolinate, now known as "chromium picolinate," as an organic nutritional source of chromium (U.S. Patent # 4,315,927). Chromium picolinate is more biologically active than inorganic forms of chromium and is presumed to have effects on the body similar to the GTF proposed by Mertz.
Chemical Make-up

Chromium picolinate is the transport form of chromium. It is stable, electrically neutral, and lipophilic. In this form, chromium is complexed with three molecules of picolinic acid, which is produced naturally in the human liver and kidney as an amino acid metabolite. However, if this form proves too stable, it might well limit bioactivity; presumably the release of the free chromic ion is required for bioactivity (McCarty, 1991). Chromium picolinate was patented in 1988 by the United States Government and licensed exclusively to the Nutrition 21 company based in San Diego, CA (U.S. Patent # 4,315,927).

Safety

Dosage

The "safe and adequate" intake of dietary chromium as established by the National Research Council and recommended by the 1989 Recommended Dietary Allowances (RDA) handbook is 50 to 200 µg per day. The average daily intake of chromium among adult Americans is approximately 30 µg, which suggests that chromium supplementation could be beneficial (Anderson & Kozlovsky, 1985). Further research is needed to determine if doses higher than the current 200 µg will have a greater effect. The recommended intake of 50 to 200 µg is based on sedentary individuals and not on active individuals or athletes. Individuals with weights greater than 165 lb may require 400 to
600 µg per day to meet their needs (Colgan, 1993).

The toxicity of chromium is about 1 mg per 100 g of body weight in humans (National Research Council [U.S.] Food Protection Committee, 1973). At this level it would require a 154-lb person to ingest 700,000 µg or 3,500 to 14,000 times the 50 to 200 µg safe and effective range recommended in the RDA. In another study conducted by Dr. Gary Evans, the toxic level of chromium picolinate was estimated to be in excess of 2.2 g/kg of body weight. This would be 100,000 times greater than the recommended nutritional intake for that same 154-lb person (Evans, 1989b).

Chromium Loss With Exercise

Exercise has been shown repeatedly to increase insulin metabolism, which in turn increases the body’s chromium requirement (Colgan, 1993). In a study done by Campbell and Anderson (1987), urinary loss of chromium increased almost five-fold after a 6-mile run, and overall daily loss of chromium was twice as much on running days as on non-running days.

Side Effects

Chromium picolinate has been available to the American consumer since 1988 as a nutritional supplement. Reports of suspected side effects have been negligible despite the fact that millions of consumers are now using it as a daily supplement (Evans, 1993). One potential concern is that diabetics who respond well to chromium picolinate may
experience hypoglycemic episodes if they fail to adjust their medications appropriately (Evans, 1989a). It is highly recommended that people with diabetes or hypoglycemia use chromium picolinate only under a doctor's supervision.

**Insulin Metabolism**

**Description**

Insulin allows cells to take in glucose in response to an increase in blood sugar levels. It also regulates the use and storage of glucose, carbohydrate, protein, and fat within the body and keeps the body in homeostasis when these are involved. After protein is digested into its constituent amino acids, insulin facilitates entry of these amino acid building blocks into muscle cells. Once inside the cell, they are built into muscle proteins, again under the influence of insulin (Riales, 1979).

**Insulin Sensitivity**

Chromium helps cells, particularly skeletal muscle, bind insulin, which increases the efficiency of the active insulin in the body. "Unless you have diabetes, you have all the insulin you need, because your body can make it instantly. To take extra insulin would be highly toxic to the non-diabetic" (Colgan, 1993, p. 314). Because chromium picolinate has been extremely effective in potentiating insulin action in humans and is lipophilic, it is suspected that as a complex, chromium may actually exert its influence in the plasma membrane of the cell (Evans & Bowman, 1992).
Evans and Bowman (1992) suggested that the number of insulin receptors on cells grown in the presence of chromium picolinate is greater than the number of insulin receptors on cells grown without chromium picolinate present. Thus, the increased efficiency and sensitivity to insulin may be due to an increased number of binding sites on the cells. "The effects of exercise on insulin sensitivity are regional, with increased sensitivity confined to the previously exercised muscle groups, combined with decreased insulin sensitivity in the non-exercised muscles" (Devlin, 1992, p. 1693).

**Blood Glucose Levels**

By increasing the rate of insulin internalization into the cells, the body can adapt to change more quickly and efficiently by maintaining blood glucose levels with a minimum output of insulin by the pancreas. In a controlled study at Mercy Hospital, San Diego, CA, Press, Geller, and Evans (1990) found that, in diabetics, chromium picolinate reduced the fasting blood sugar by 18% and significantly improved blood sugar stability. Fasting blood sugar levels were reduced by 35% over an 8-week period in a study of American Chippewa Indians with non-insulin dependent diabetes mellitus (Evans, 1991).

**Body Composition**

"The supplemental use of chromium picolinate helps maintain and even build additional muscle, while fat is burned for energy" (Challem, 1994, p. 29). Although people who exercise benefit the most from chromium picolinate, sedentary individuals benefit as well. Kaats, Fisher, and Blum (1991) found that overweight people taking 200 µg of
chromium picolinate lost an average of 3.0 lb in body fat and gained 1.5 lb in muscle after 2 months. It was noted by Evans (1989a) and Press et al. (1990) that the effects of chromium picolinate could be measured after only 6 weeks of supplementation. Those taking 400 µg of chromium picolinate lost an average of 4.6 lb in fat and gained 1.0 lb in muscle.

Recent studies have been prompted by the knowledge that insulin has an anabolic effect on skeletal muscle and other tissues, promoting amino acid uptake and protein synthesis and retarding protein degradation (McCarty, 1991). It can be reasoned that good chromium nutrition might potentiate this anabolic effect by promoting greater insulin activity. Initial studies suggested that supplemental chromium picolinate in exercising young adults tended to promote the development of lean body mass and muscle bulk (McCarty, 1991).

Insulin also had a direct anabolic effect in promoting the manufacture of somatomedins by the liver (Draznin & Shlomo, 1989). Somatomedins mediated the effect of human growth hormone as well as increased ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) synthesis thus acting as a growth factor. Without somatomedins, very little muscle growth occurred (Rudman, 1985).
"Proteins play only a minor role as a substrate during exercise, with fat and carbohydrate serving as the major sources of energy during activity in the healthy individual consuming a balanced diet" (Powers & Howley, 1994, p. 58). During moderate physical exercise, both decreases in insulin secretion and increases in glucagon secretion have been found to play important roles in the prevention of hypoglycemia. These changes in insulin and glucagon, as well as the increased metabolism of skeletal muscle during exercise, cause a shift in substrate utilization.

Endurance Exercise

During the transition from rest to submaximal exercise almost all of the energy is derived from glycogen stored in the active muscles. During the subsequent 20 min of exercise, liver and muscle glycogen provide about 40% to 50% of the energy requirement, with the remaining energy coming from fat breakdown. As exercise continues and glycogen stores become reduced, however, an increasingly greater percentage of energy is supplied through fat metabolism (McArdle, Katch, & Katch, 1991).

Blood glucose is transported into the cell more rapidly in the presence of chromium picolinate by making the cell membrane more permeable. Chromium picolinate also increases the effectiveness of lipase, which is responsible for the breakdown of triglycerides to fatty acids and glycerol, and thus increases fat metabolism during
submaximal exercise (Powers & Howley, 1994). These two factors coupled together allow the body to increase the rate of fat metabolism through an increased efficiency of carbohydrate metabolism during exercise.

**Resistance Exercise**

Resistance exercise, which is usually in the form of short bouts of maximal exertion, predominantly requires the use of blood glucose and muscle glycogen stores for fuel. Because of the short duration of bouts of resistance exercise, the body does not rely as much on fat as a fuel source as in aerobic exercise, because there is enough time between bouts to replace glycogen stores in the muscle. In bouts lasting approximately 60 s the body obtains about 70% of the energy from carbohydrates and the remaining 30% from fats (Powers & Howley, 1994). Shorter bouts of exercise obviously use a greater percentage of carbohydrate as a fuel source.

**Respiratory Exchange Ratio**

R, the ratio of CO₂ production to O₂ consumption, indicates which substrate is primarily being used by the body for fuel. An R value of 1.00 represents 100% carbohydrate metabolism, and an R value of 0.70 represents 100% fat metabolism (Powers & Howley, 1994). The measured values in individuals usually lie somewhere between these two values and rarely indicate that someone is burning only one substrate at any given time.
CHAPTER III

DESIGN AND METHODOLOGY

The purpose of the study was to investigate the effects, on college age males (ages 18 to 25 years), of ingesting chromium picolinate over a 6 week period when administered as a supplement to their diet. Respiratory exchange ratio (R) (at a submaximal state), body fat percentage, and lean body mass were measured to determine whether a shift in substrate utilization, reduction in percentage of body fat, or an increase in lean body mass occurred over the 6-week period. The study included the following procedural steps: (a) selection of subjects, (b) instrumentation, (c) testing procedures, (d) design of study, and (e) treatment of data.

Selection of Subjects

All of the subjects were volunteers who were enrolled at Western Michigan University during the course of the investigation. The characteristics of the subjects included the following: (a) males; (b) ages 18 to 25 years; (c) individuals without known blood glucose regulatory problems, such as hypoglycemia or diabetes; and (d) individuals who had given their informed consent. Appendix A contains the Human Subjects Institutional Review Board's letter of approval. Appendix B contains a copy of the consent form each subject signed before participation in the study. Appendix C contains
a copy of the screening form used to eliminate subjects with known blood glucose regulatory problems. Appendix D contains the data recording form used to record subject data throughout the study.

**Instrumentation**

The instruments used for gathering the data were selected based on availability and reliability. The hydrostatic tank and weighing instrumentation in the laboratory at Western Michigan University were used. The hydrostatic weighing was done using a water tank with dimensions of 4 ft by 4 ft by 4 ft. Underwater weights were measured using an Omega Engineering CCA - 215 load cell integrated with an Omega DP40 series indicator. The analog-to-digital conversion was accomplished with a Zenith 386/20 computer on locally produced software. Body weight was measured using a physician's scale. R values were measured using the Quinton Q-plex 1 metabolic cart. Subjects walked on a Quinton (model 18-60) treadmill. Subjects' vital capacities were measured using a Micro Medical Limited microspirometer. Chromium picolinate was obtained from NOW Foods, based in Glendale Heights, IL.

**Testing Procedures**

**Initial Procedure**

All testing was completed in the Exercise Physiology Lab in the University Recreation Center, at Western Michigan University, Kalamazoo. Prior to the study, a
consent form was signed and dated by each of the subjects. Within the consent form, the testing procedure and possible risks of the study were explained. Subjects were asked to wear clothing and footwear that were functional and appropriate for walking on the treadmill as well as bring a swimsuit for having their body composition measured in the hydrostatic tank. Subjects were allowed time to become comfortable with the treadmill and metabolic cart before the testing process began. The supplementation, placebo, and control groups maintained their current activity levels and nutrition schedule for the following 6-week period. After the 6-week period, R value, body fat percentage, and lean body mass were calculated again using the same protocol.

Body Weight

Body weight was measured using a Health-O-Meter balance scale (Continental, Chicago, IL). The subject was instructed to wear clothing that could be worn in the hydrostatic tank. The subject was instructed to stand erect and still on the scale while the measurement was taken (Lohman, Roche, & Martorell, 1988).

Respiratory Exchange Ratio

R values were measured using the Quinton metabolic cart. The subjects were instructed to walk on a Quinton treadmill at a speed of 3.5 mph. R values were taken at 20-s intervals for 3 min after a steady state was achieved. Baseline R values were obtained by calculating the mean R value of two trials, one from each of 2 different days.
Hydrostatic Weighing

After obtaining an R value on the 2nd day, each subject had his percentage of body fat and lean body mass determined using hydrostatic weighing. Hydrostatic weighing is considered the gold standard for validating all other methods of measuring body composition. The hydrostatic weighing procedure estimates the body fat percentages at an accuracy level of ± 2.5% of the true value (Lohman, 1981). Hydrostatic weighing uses Archimedes' principle. When submerged, body muscle and bone sink due to densities higher than that of water (Kreighbaum & Barthels, 1990).

Residual volume (RV) was estimated using the formula of RV = 0.24 x VC for males. Vital capacity was measured using a Micro Medical Limited microspirometer. Body mass was measured in water and in air. The hydrostatic weighing was done in a 64 cubic foot tank with an observation window. The weighing was done until the subject had three trials within 1% of each other or a maximum of 10 trials, taking either the mean of the last 3 trials or the mean of the 3 trials within 1%. Body density was calculated using the formula recommended by Powers and Howley (1994). The Siri equation for percent body fat was used to calculate body fat percentages (Powers & Howley, 1994). The formula, lean body mass = body mass - fat mass, was used to calculate lean body mass (McArdle et al., 1991).

Design of Study

The subjects were randomly assigned to either the chromium picolinate
supplementation group, the placebo group, or the control group by someone not directly involved in the study. The random assignments were sequestered until all data were collected. The study was double blind in that neither the subjects nor the investigator was aware of which subjects received the supplement and which received the placebo. All groups participated in the pretest in the week prior to the treatment. Based on the results of previous studies, a 6-week supplementation period was selected. After the 6-week treatment period, the posttest was administered in the same manner as the pretest. Both the pretest and the posttest were administered by the investigator and/or other graduate students at Western Michigan University who had been instructed and trained by the investigator.

Treatment of Data

A split-plot factorial analysis of variance (ANOVA) was used to determine if significant differences in R value, body fat percentages, and lean body mass occurred among the chromium picolinate group, the placebo group, and the control group. Pretest and posttest trials were compared to determine the effect of chromium picolinate supplementation. The 2V program from the BMDP statistical package was used to calculate the ANOVAs.
CHAPTER IV

RESULTS AND DISCUSSION

In this study the researcher investigated the effects of 6 weeks of chromium picolinate supplementation on R value, body fat percentage, and lean body mass. Results were discussed under the following subheadings: (a) Independent Variables, (b) Subject Demographics, (c) Respiratory Exchange Ratio, (d) Body Fat Percentage, and (e) Lean Body Mass. A split-plot factorial ANOVA design was used to analyze the dependent variables R, body fat percentage, and lean body mass. The independent variables in the design were the repeated measure, pretest and posttest, and the treatment groups, chromium picolinate, placebo, and control. All hypotheses were tested statistically at the .05 level of significance.

Results

Independent Variables

Subjects were randomly assigned to either the chromium picolinate supplementation group, the placebo group, or the control group. The chromium picolinate group ingested 1.6 mg of chromium picolinate each day for 6 weeks, which contained 200 µg of chromium. The placebo group ingested 1.6 mg of lactose each day for 6 weeks, and the control group received nothing. All groups participated in the pretest in the week
prior to treatment. The subjects were placed in the treatment groups by the research advisor, making the study double blind, so that neither the subjects nor the investigator was aware of which subjects received the supplement and which received the placebo.

Subject Demographics

The average ages for the subjects in the chromium picolinate supplementation, placebo, and control groups were 20.1 years, 20.9 years, and 19.9 years, respectively. Although the study began with 60 subjects, 20 in each group, the number of subjects completing the study were 15, 19, and 16 in the picolinate supplementation, placebo, and control groups, respectively. The initial mean R values for the chromium picolinate, placebo, and control groups were 0.83, 0.85, and 0.82, respectively. The initial body fat percentage means were 13.84%, 16.91%, and 13.57% for the chromium picolinate, placebo, and control groups, respectively. The initial lean body mass means were 142.13 lb, 142.82 lb, and 141.87 lb for the chromium picolinate, placebo, and control groups, respectively.

Respiratory Exchange Ratio

Means and standard deviations for R for the chromium picolinate, placebo, and control groups are displayed in Table 1. The mean R values, 0.83 and 0.82, did not change from the beginning to the end of the 6-week period for the chromium picolinate supplementation and control groups, respectively. The mean R value decreased from 0.85 to 0.84 for the placebo group. The standard deviations (SD) were fairly constant for all
groups from pretest to posttest. The SD for R was lower at the end of the 6-week period, 0.03, than prior to treatment, 0.05, in the chromium picolinate group. The SD for the placebo and control groups changed from 0.04 and 0.05 to 0.05 and 0.03, respectively for the pretest and posttest.

Table 1
Means and Standard Deviations of Respiratory Exchange Ratio

<table>
<thead>
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<th>Treatment</th>
<th>Chromium Picolinate</th>
<th>Placebo</th>
<th>Control</th>
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<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td>Pretest</td>
<td>0.83 0.05</td>
<td>0.85 0.04</td>
<td>0.82 0.05</td>
</tr>
<tr>
<td>Posttest</td>
<td>0.83 0.03</td>
<td>0.84 0.05</td>
<td>0.82 0.03</td>
</tr>
</tbody>
</table>

A split-plot factorial ANOVA design was used to analyze the dependent variable, R. The ANOVA summary table for R is presented in Table 2. The analysis of variance revealed no significant differences among the chromium picolinate, placebo, and control groups in the dependent variable, R, F(2, 47) = 2.62, p > .05. There was no significant differences between trials, F(1, 47) = 0.10, p > .05. There was no significant interaction effect between treatments and trials, F(2, 47) = 0.08, p > .05.
Table 2

Analysis of Variance Summary Table for Respiratory Exchange Ratio

<table>
<thead>
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<th>Source</th>
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<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (TR)</td>
<td>0.01230</td>
<td>2</td>
<td>0.00615</td>
<td>2.62</td>
</tr>
<tr>
<td>Subjects w/ groups</td>
<td>0.11031</td>
<td>47</td>
<td>0.00235</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials (T)</td>
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<td>0.00008</td>
<td>0.10</td>
</tr>
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<td>TR x T</td>
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<td>0.00007</td>
<td>0.08</td>
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<tr>
<td>T x Subj w/ groups</td>
<td>0.03964</td>
<td>47</td>
<td>0.00084</td>
<td></td>
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</table>

Body Fat Percentage

Means and standard deviations for body fat percentages for the chromium picolinate, placebo, and control groups are displayed in Table 3. The mean body fat percentage for the chromium picolinate supplementation group decreased from 13.84% to 13.69% over the 6-week period. The body fat percentage increased in the placebo group from 16.91% to 17.32% and decreased in the control group from 13.57% to 13.49% during the 6-week period. The SD decreased for all three groups. The SD dropped to 5.96 from 6.04, to 6.18 from 7.04, and to 5.72 from 6.07 for the chromium, placebo, and control groups, respectively.
Table 3
Means and Standard Deviations of Body Fat Percentage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Chromium Picolinate</th>
<th>Placebo</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Pretest</td>
<td>13.84</td>
<td>6.04</td>
<td>16.91</td>
</tr>
<tr>
<td>Posttest</td>
<td>13.69</td>
<td>5.96</td>
<td>17.32</td>
</tr>
</tbody>
</table>

A split-plot factorial ANOVA design was also used to analyze the dependent variable, body fat percentage. The ANOVA summary table for body fat percentage is presented in Table 4. The analysis of variance revealed no significant differences among the treatments, (chromium picolinate, placebo, and control group) for body fat percentage, $F(2, 47) = 1.88, p > .05$. There was no significant difference between trials, $F(1, 47) = 0.06, p > .05$. There was no significant interaction effect between treatments and trials, $F(2, 47) = 0.54, p > .05$.

Lean Body Mass

Means and standard deviations for lean body mass for the chromium picolinate, placebo, and control groups are displayed in Table 5. The mean lean body mass for the
Table 4

Analysis of Variance Summary Table for Body Fat Percentage

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (TR)</td>
<td>283.92761</td>
<td>2</td>
<td>141.96381</td>
<td>1.88</td>
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<tr>
<td>Subjects w/ groups</td>
<td>3558.38095</td>
<td>47</td>
<td>75.71023</td>
<td></td>
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<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials (T)</td>
<td>0.08681</td>
<td>1</td>
<td>0.08681</td>
<td>0.06</td>
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<tr>
<td>TR x T</td>
<td>1.63947</td>
<td>2</td>
<td>0.81973</td>
<td>0.54</td>
</tr>
<tr>
<td>T x Subj w/ groups</td>
<td>71.03554</td>
<td>47</td>
<td>1.51139</td>
<td></td>
</tr>
</tbody>
</table>

Chromium picolinate, placebo, and control groups increased over the 6-week period from 142.13 lb to 142.79 lb, 142.82 lb to 143.78 lb, and 141.87 lb to 142.83 lb, respectively. The SD decreased from 15.25 to 14.84 in the chromium picolinate group. SDs for the placebo and control groups increased from 17.08 and 11.44 to 17.67 and 12.76, respectively.

A split-plot factorial ANOVA design was also used to analyze the dependent variable, lean body mass. The ANOVA summary table for lean body mass is presented in Table 6. The analysis of variance revealed no significant differences among the chromium picolinate, placebo, and control groups in lean body mass, \( F(2, 47) = 0.02, p > .05 \). There
was no significant difference between, $F(1, 47) = 3.60, p > .05$. There was no significant interaction effect between treatments and trials, $F(2, 47) = 0.05, p > .05$.

Table 5

Means and Standard Deviations of Lean Body Mass in Pounds

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Chromium Picolinate</th>
<th>Placebo</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Pretest</td>
<td>142.13</td>
<td>15.25</td>
<td>142.82</td>
</tr>
<tr>
<td>Posttest</td>
<td>142.79</td>
<td>14.84</td>
<td>143.78</td>
</tr>
</tbody>
</table>

Discussion

Based on the results of this study, there were no significant differences among the chromium picolinate, placebo, and control groups in regard to the R value, body fat percentage, or lean body mass. Similarly there were no significant differences between the trials and no significant interaction effects.

Although it was not statistically significant, there were small differences among groups for the R value. The differences were not expected. If chromium picolinate enabled the body to burn more fat, it should have resulted in a lower R value after the 6-
week supplementation period. The opposite results were found. R values increased slightly for the chromium group, but decreased for the other groups.

Table 6
Analysis of Variance Summary Table for Lean Body Mass

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (TR)</td>
<td>19.28794</td>
<td>2</td>
<td>9.64397</td>
<td>0.02</td>
</tr>
<tr>
<td>Subjects w/ groups</td>
<td>21380.10074</td>
<td>47</td>
<td>454.89576</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trials (T)</td>
<td>18.27935</td>
<td>1</td>
<td>18.27935</td>
<td>3.60</td>
</tr>
<tr>
<td>TR x T</td>
<td>0.46235</td>
<td>2</td>
<td>0.23117</td>
<td>0.05</td>
</tr>
<tr>
<td>T x Subj w/ groups</td>
<td>238.91040</td>
<td>47</td>
<td>5.08320</td>
<td></td>
</tr>
</tbody>
</table>

There was a slight gain in lean body mass within all groups over the 6-week period. As can be seen in Table 5, all three groups experienced a small increase in lean body mass. This may have occurred as a result of a learning effect associated with the hydrostatic weighing procedure. Also, although subjects were instructed not to do so, some subjects may have increased their workouts or weight training programs over the 6-week period.

The only other difference worth noting was the body fat percentage among
groups. As can be seen in Table 3, the mean body fat percentage decreased slightly for the chromium group and increased slightly for the placebo group.

The results of this investigation were not in agreement with the findings of Evans (1989a) or Hasten, Rome, Franks, and Hegsted (1992). Both studies included a chromium picolinate supplementation group and a placebo group, but neither included a control group.

Evans (1989a) reported the results for two separate studies that found significant decreases in body fat percentages as well as significant increases in lean body mass in college-age males after 6 weeks of resistance training in combination with 200 µg per day of chromium picolinate supplementation. The sample size of his first study was quite small, N = 10. Also, anthropometric measurements and skinfold measurements were used to determine body composition. Predictions based on skinfold measurements are generally less accurate than predictions based on hydrostatic weighing when used to estimate body fat percentage and lean body mass. Although Evans (1989a) reported, "In both of our studies, the young men who ingested a daily supplement of chromium picolinate showed an increase in lean body mass and a decrease in body fat" (p. 174), he indicated in his first study that, "the body weight of the men who consumed chromium picolinate increased significantly by 2.2 kg and there was a slight but not significant increase in percent fat" (p. 170). These statements appear to be in conflict. The lack of tables in the article may have contributed to this confusion or misinterpretation of data. In the second investigation, Evans (1989a) reported a 2.7% decrease in percentage body fat and a 1.8 kg increase in lean body mass after only 14 days. Again, if hydrostatic weighing had been
used instead of skinfold measurements, these results may have been different.

Hasten et al. (1992) found significant differences over a 12-week period between the pretest and posttest for body weight, sum of three circumferences, and sum of three skinfolds. Methodological limitations in this experiment may have accounted for the positive results. Anthropometric measurements were used to estimate changes in body composition rather than hydrostatic weighing.

The present investigation agreed with the findings of more recent studies done by Clancy et al. (1994) and Hallmark et al. (1996). They studied the effects of chromium supplementation, 200 µg in the form of 1.6 mg chromium picolinate, and resistive exercise training on body composition, muscle strength, and urinary chromium loss. Both studies concluded that no significant differences in body composition accompanied the dietary supplementation of chromium picolinate. Clancy et al. used the sum of seven skinfolds as well as hydrostatic weighing to determine body composition for 38 football players and found no significant differences over 9 weeks. Similarly, Hallmark et al. used the sum of 6 skinfolds as well as hydrostatic weighing to determine body composition. Likewise, there were no significant changes in body composition or lean body mass over a 12-week period.
SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the effect of 6 weeks of chromium picolinate supplementation on the R value, body fat percentage, and lean body mass. The research was discussed under the following headings: (a) Summary, (b) Findings, (c) Conclusions, and (d) Recommendations.

Summary

The purpose of the study was to investigate the effects, on college age males (ages 18 to 25 years), of ingesting chromium picolinate over a 6 week period when administered as a supplement to their diet. Respiratory exchange ratio (R) (at a submaximal state), body fat percentage, and lean body mass were measured to determine whether a shift in substrate utilization, reduction in percentage of body fat, or an increase in lean body mass occurred over the 6-week period. The 50 male subjects investigated were randomly placed into 3 groups: (1) chromium picolinate group, n = 15; (2) placebo group, n = 19; and (3) control group, n = 16. All subjects were instructed to maintain daily activities.

R values were measured using the Quinton Q-plex 1 metabolic cart. The subjects were instructed to walk on a Quinton (model 18-60) treadmill at a speed of 3.5 mph. R
values were taken at 20-s intervals for 3 min after a steady state was achieved. Body fat and lean body mass were measured using hydrostatic weighing. The hydrostatic weighing was done using a water tank with dimensions of 4 ft by 4 ft by 4 ft. Underwater weights were measured using an Omega Engineering CCA - 215 load cell integrated with an Omega DP40 series indicator. The analog-to-digital conversion was accomplished with a Zenith 386/20 computer on locally produced software. The hydrostatic weights were taken until the subject had 3 trials within 1% of each other or a maximum of 10 trials, taking either the mean of the last 3 trials or the mean of the 3 trials within 1%.

Three split-plot factorial ANOVAs were calculated by computer using the following dependent variables: (a) R, (b) body fat percentage, and (c) lean body mass. The independent variables in the design were the repeated measure, pretest and posttest, and the treatment groups, chromium picolinate, placebo, and control. All hypotheses were tested statistically at the .05 level of significance.

Findings

None of the research hypotheses were supported. The analysis of variance revealed no significant differences among the chromium picolinate, placebo, and control groups for the dependent variable, R, \( F(2, 47) = 2.62, p > .05 \). There was no significant difference between trials, \( F(1, 47) = 0.10, p > .05 \). There was no significant interaction effect between treatments and trials, \( F(2, 47) = 0.08, p > .05 \). The analysis of variance revealed no significant differences among the chromium picolinate, placebo, and control groups for body fat percentage, \( F(2, 47) = 1.88, p > .05 \). There was no significant
difference between trials, $F(1, 47) = 0.06, p > .05$. There was no significant interaction effect between treatments and trials, $F(2, 47) = 0.54, p > .05$. The analysis of variance revealed no significant differences among the chromium picolinate, placebo, and control groups for lean body mass, $F(2, 47) = 0.02, p < .05$. There was no significant difference between trials, $F(1, 47) = 3.60, p > .05$. There was no significant interaction effect between treatments and trials, $F(2, 47) = 0.05, p > .05$.

Conclusions

Based on the results of this study, it appeared that 6 weeks of dietary supplementation of 200 µg of chromium picolinate by sedentary males, aged 18 to 25 years, does not significantly affect R value, body fat percentage, or lean body mass.

Recommendations

Further research is warranted to confirm the present findings and to examine the effects of chromium picolinate supplementation over a longer supplementation period and at higher doses. Further testing should be done to explore the use of chromium picolinate by women as well as men. Several suggestions to improve the testing of a fasting R value are: (a) control the subjects' meal the night prior to testing, (b) test all subjects in the morning after a night of fasting, (c) have the subjects walk longer on the treadmill, and (d) have the subjects walk at a slower speed.
Appendix A

Human Subjects Institutional Review Board Approval,
Western Michigan University
Date: October 4, 1995

To: Matthew Beaty

From: Richard Wright, Chair

Re: HSIRB Project Number 95-09-02

This letter will serve as confirmation that your research project entitled "The effects of chromium picolinate supplementation on body fat, lean body mass and respiratory exchange ratio" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you must seek specific approval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 4, 1996

xc: Roger Zabik, HPER
Appendix B

Informed Consent Form
I have been invited to participate in an experimental research project entitled "The Effects of Chromium Picolinate Supplementation on Body Fat, Lean Body Mass, and Respiratory Exchange Ratio." I understand that this research is intended to determine if the dietary supplementation of 200 µg of chromium, in the form of chromium picolinate, will affect the body fat, lean body mass, or respiratory exchange ratio of an individual. I further understand that this project is Matt Beaty's master's thesis in the department of Health, Physical Education & Recreation at Western Michigan University.

Chromium, like iron or zinc, is an essential mineral in the human diet. Chromium is an essential insulin cofactor. A deficiency in chromium affects the insulin sensitivity of the cells, which in turn slows the burning of food for energy. If the food we consume isn't being used for fuel, the body then converts it to fat. There are no known side effects to the ingestion of 200 µg of chromium and the toxic levels have been found to be, at the minimum, 3,500 times the dose being given.

My agreement to participate indicates that I will attend four 45-min to 1-hour individual sessions. Two of these sessions will take place prior to the 6-week supplementation period, and two will take place after the 6-week period. These sessions will take place in the Exercise Physiology Laboratory in the University Recreation Center, Gary Wing. These sessions will involve walking on a treadmill at 3.5 mph (a fast walking pace), while breathing into a mouthpiece for about 10 minutes to determine respiratory exchange ratio. The 3.5 mph rate is approximately the same pace at which most students walk to classes. In addition, the second and fourth sessions will involve the determination of body fat and lean body mass by hydrostatic weighing. Hydrostatic weighing will include my being submerged in water tank that is a 4' x 4' x 4' tank with a glass side or viewing window.

There will be three groups, two that receive a capsule (supplement or placebo) that will be taken daily. One group receives chromium picolinate, and one group gets a natural dietary supplement that does not include chromium picolinate. The third group (control) will receive no supplement. If I am placed into one of the two groups that receives capsules, I agree to take the supplement as directed. I agree that I will not pull the capsule apart, it is important to keep the capsule intact as one of the substances used in the research can be an irritant to the skin.
As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or treatment will be made available to me except as otherwise stated in this consent form. I am aware that there may be some risk of injury, such as muscle soreness or possible heart attack. However, appropriate measures will be taken to minimize these risks. The investigators and others assisting in the data collection are all CPR and First Aid trained. Emergency response procedures are also posted in the Exercise Physiology lab where all testing will take place. I also understand that I may terminate my involvement with this research for any reason at anytime without affecting my academic evaluations in any way.

I may benefit from my participation by knowing my percentage of body fat and lean body mass. I may also gain insight as to the substrate that I am burning at low intensity activities such as walking at 3.5 mph. I may also gain knowledge as to the importance of minerals in my diet.

I am aware that all information and data pertaining to my participation is confidential. My name will only appear on my data recording form and no individual names will be printed on any paper or reports other than this form, which will be seen only by the investigator and those helping to test. All data will be retained for a period of 3 years in a locked file controlled by the principal investigator. At the conclusion of the study there will be a short individual debriefing meeting in which all subjects who received an supplement will be informed as to which group (supplementation or placebo) they were assigned to.

If I have any questions or concerns about this study I may contact Matt Beaty at 387-2689 or Dr. Zabik at 387-2713. I may also contact the chair of the Human Subjects Institutional Review Board (387-8293) or the Vice President for Research at 387-5926. I affirm that I am between the ages of 18 and 25 years old and free of any known blood glucose regulatory problem such as hypoglycemia or diabetes. My signature below indicates that I understand the purpose and requirements of the study and that I agree to participate.

__________________________  ________________
Signature  Date
Appendix C

Subject Screening Form
Subject Screening Form

1. Do you have any known blood glucose regulatory disease such as diabetes or hypoglycemia? (Y / N)

2. Are you allergic to any food substances?

3. If you answered yes to question #2, please list the food allergies that you have.
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________

An answer of yes to item 1 will result in the subjects elimination from the study. Anyone indicating a food allergy to milk or dairy products will be placed in a group other than the placebo group by the principal investigator.
Appendix D

Data Recording Form
DATA RECORDING FORM

Subject's Name ___________________________ Date ___________
Age ______ Phone Number _______________________

### Initial

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<th>Day 4</th>
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### HYDROSTATIC WEIGHING

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<td>__ °C</td>
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<tr>
<td>Water Temperature</td>
<td>__ °C</td>
<td>__ °C</td>
</tr>
<tr>
<td>Body Weight</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Tare Weight</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Trial 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.</td>
<td></td>
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</tr>
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<td>% BF</td>
<td>__</td>
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### Post Supplementation

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<th>Day 4</th>
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<td></td>
</tr>
<tr>
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<td>__ °C</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>__ °C</td>
<td>__ °C</td>
</tr>
<tr>
<td>Body Weight</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Tare Weight</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>Trial 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.</td>
<td></td>
<td></td>
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<tr>
<td>% BF</td>
<td>__</td>
<td>__</td>
</tr>
</tbody>
</table>

LBM


