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Combined dietary chromium picolinate supplementation and an exercise program leads to a reduction of serum cholesterol and insulin in college-aged subjects

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The effects of a 13 week daily chromium picolinate supplementation (1000 μg/day) or placebo in a double blind design were examined using 20 college-aged students of both genders who were participating in a combined aerobic and resistance exercise program. Strength, upper leg/upper arm circumferences, lean body mass, total cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), triglyceride, glucose, and insulin levels were examined in these subjects before and after chromium picolinate supplementation with exercise. Exercise alone or coupled with chromium picolinate supplementation did not produce significant changes in strength, lean body mass, HDL, triglyceride, ferritin, or glucose levels. However, chromium picolinate supplementation with exercise did decrease total cholesterol ($P < 0.001$), *LDL* ($P < 0.002$), *and insulin* ($P < 0.02$) *levels.* (J. Nutr. Biochem. 9:471–475, 1998) © *Elsevier Science Inc. 1998*

Keywords: chromium picolinate; exercise; insulin; cholesterol; LDL

Introduction

Trivalent chromium (Cr^{3+}) seems to be an element essential to normal carbohydrate, lipid, and protein metabolism.[1–3] Moreover, a recent study by the U.S. Department of Agriculture concluded that most Americans do not receive enough trivalent chromium in their diets.[4] A diet severely deficient in chromium can lead to hypercholesterolemia and insulin resistance.[1,2,5]

One of the most popular forms of supplemental chromium sold at food and drug stores is chromium picolinate. In cell culture, chromium picolinate treatment has resulted in increased membrane fluidity and rate of insulin internalization.[6] Chromium picolinate and other forms of trivalent chromium have been shown to improve the insulin response to glucose in rats[2] and have been used with some success to control blood glucose levels in patients with type I and type II diabetes.[7–10] Other studies have reported that chromium picolinate supplementation is associated with lower serum triglyceride levels in patients with type II diabetes.[11]

There also seems to be a link between trivalent chromium metabolism and exercise. Urinary chromium excretion increases with exercise[12,13] and increased excretion combined with a diet deficient in chromium may put athletes at a particular risk for chromium deficiency. Another line of evidence to suggest a positive role for chromium picolinate in athletes is provided by a study that showed that this supplement is associated with an increase in lean body weight in exercising female subjects.[14] Other studies have shown that chromium picolinate supplementation correlates with increases in lean body mass in exercising humans[15] and parallel studies in various animals have reported increased lean muscle mass with chromium supplementation.[16,17]

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Received February 10, 1998; accepted May 12, 1998.

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0955-2863/98/$19.00
PII S0955-2863(98)00043-6

This study was initiated to further evaluate the effects of trivalent chromium supplementation in young, exercising, and otherwise healthy men and women. We chose our study population and experimental model because so many health conscious people are taking chromium picolinate in combination with an exercise program. The majority of chromium supplementation literature focuses on the effects of chromium on gluco-regulatory systems and lipid levels in a diseased or obese population. After reviewing the current literature, it seemed that there was a need for a study of the effects of a large supplemental dose (1000 μg/day) over several months in young healthy exercising subjects.

Materials and methods

Experimental grouping and chromium picolinate supplementation

This study was conducted with the approval of the Internal Review Board Committee for Human Experimentation at East Carolina University. Written, informed consent was obtained before chromium picolinate supplementation of 35 healthy college-aged students taking an exercise class who were asked to participate in the study. These subjects were divided equally into two groups using gender and weight as balancing parameters. In this double-blind study, one group received 1000 μg of chromium picolinate in the form of two 500 μg capsules per day for 13 weeks. The second group received two placebo capsules per day for 13 weeks. The subjects were instructed to take one capsule in the morning with breakfast and one with the evening meal. Chromium picolinate and placebo capsules were graciously provided by Nutrition 21 Inc. (San Diego, CA USA). During this 13-week period, both groups met in an exercise class every Monday and Wednesday for a 50-minute period that was composed of approximately three periods of resistance exercise for every period of aerobic exercise. The resistance component of the program consisted of a variety of activities including bench press, squat, lat pull down, military press, leg extensions, and hamstring curls. The aerobic component of the exercise program consisted of short run/walk periods of 1 to 1.5 miles or basketball.

Compliance

Compliance was a primary concern during the study and several methods were used to ensure that the subjects were consuming the supplement/placebo capsules and attending the exercise class. Phone contact was made with experimental subjects as needed to answer questions about the study and remind the subjects of data gathering days. Subjects were also under direct professional supervision during the exercise program and their attendance at exercise sessions was recorded. Furthermore, the individual bottles of chromium picolinate or placebo for each subject were returned at the 6 week mark in the study and the capsules were counted to estimate compliance. Compliance surveys were also administered in the 13th week of the training study. Ten of the original 35 subjects were removed before data analysis because of concerns about compliance.

Data gathering and analysis

Data were collected during the first and thirteenth weeks of the study. This involved drawing blood from the subjects for fasting total cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), triglyceride, insulin, ferritin, and blood glucose levels. Total cholesterol, HDL, and glucose levels were analyzed using a Gemstar II from Schiapparelli Biosystems (Fairfield, NJ). LDL levels were calculated using the Friedewald equation.[18] Insulin and ferritin levels were analyzed using an IMX analyzer from Abbot Laboratories (Abbot Park, IL). The sum of two body circumferences was obtained by measuring the circumferences of contracted upper arms and adding this to a circumference measurement taken from the subject's contracted thigh 15 cm above the knee. Subjects performed strength tests using one repetition and ten repetitions maximum in both bench press and squat exercises. The subjects were weighed and a standard seven site skin fold measurement was taken to determine lean body mass. All statistics with these measurements were performed using the Student's paired *t*-test.

Results

There were no significant differences in any parameter prior to the initiation of the study between the chromium supplemented and placebo groups. After noncompliant subjects were removed, both groups on average attended the vast majority of exercise classes (>90%). There were no complaints or perceivable side effects reported from either group.

There were no significant differences between groups in serum levels of ferritin, fasting glucose, HDL, or triglyceride (*Table 1*). There were significant differences in serum total cholesterol ($P < 0.001$, *Figure 1*), insulin ($P < 0.02$, *Figure 2*), and LDL ($P < 0.002$, *Figure 3*) between the supplemented and placebo groups post exercise. There were no significant differences in weight loss, lean body mass, or upper leg/upper arm circumferences, or strength in either group (*Table 1*).

Discussion

Despite the many commercial claims that chromium picolinate is a weight loss agent or "fat burner," this study found no synergistic or additive effects on weight loss or lean body mass when chromium picolinate was added to an exercise regimen. Likewise, chromium picolinate supplementation did not have significant effects on strength. It also should be noted that our study found no effect on lean body mass or strength in the placebo supplemented exercise group. We would not like to conclude that exercise has no effect on these parameters, but rather believe that the duration of our study, intensity of exercises performed, and sensitivity of our devices may have contributed to the negative result. We recommend further investigation in these areas.

Chromium picolinate did seem to have an advantageous effect on serum total cholesterol, LDL, and insulin levels. These findings suggest that a moderate exercise program coupled with chromium picolinate supplementation improves some serum lipid parameters and insulin levels. Furthermore, our data indicate that the 1000 μg per day chromium picolinate supplementation does not elevate or depress normal blood glucose values.

Recently, there has been some concern that chromium picolinate supplementation could adversely affect iron metabolism and perhaps lead to iron deficiency.[19] If true, this is potentially an important concern for anyone receiving the supplement. To assess the effects of chromium supplementation on iron stores in our study population, serum ferritin

Table 1 Pre- and post-exercise values for chromium picolinate (+CrPic) and placebo (−CrPic) groups

Value	Preexercise		Postexercise	
	−CrPic	+CrPic	−CrPic	+CrPic
Total cholesterol (mg/dL)	183.4 ± 23.3	183.2 ± 40.2	163.9 ± 21.6	150.3 ± 29.9*
HDL (mg/dL)	46.0 ± 11.3	44.4 ± 12.3	40.6 ± 10.2	45.4 ± 10.6
LDL (mg/dL)	106.9 ± 12	112.0 ± 41.0	105.6 ± 32.0	88.8 ± 32.2*
Triglycerides (mg/dL)	148.9 ± 83.0	114.4 ± 92.2	128.0 ± 59.7	79.6 ± 35.7
Insulin (μU/mL)	9.23 ± 7.34	9.86 ± 6.31	10.56 ± 8.26	5.0 ± 2.9*
Glucose (g/dL)	93.2 ± 7.1	88.4 ± 8.0	84.1 ± 11.0	81.2 ± 3.2
Weight (kg)	65.7 ± 10.1	69.2 ± 19.0	65.8 ± 9.2	69.1 ± 17.8
Thigh (cm)	47.7 ± 3.1	46.1 ± 11.8	48.1 ± 2.9	50.0 ± 5.1
Bicep (cm)	27.5 ± 2.6	25.2 ± 6.8	28.1 ± 3.1	27.2 ± 3.5
Thigh + bicep (cm)	75.2 ± 5.3	71.3 ± 17.9	76.2 ± 5.5	77.2 ± 8.1
% BF	21.3 ± 11.0	24.9 ± 7.7	20.5 ± 11.2	23.1 ± 7.9
Bench press (kg)	50.2 ± 28.4	61.7 ± 36.3	53.8 ± 31.2	63.2 ± 38.2
Leg press (kg)	122.7 ± 68.9	163.0 ± 99.7	115.0 ± 30.7	170.9 ± 99.6
Bench (kg) + leg press (kg)	172.2 ± 97.5	224.8 ± 133.0	166.2 ± 43.7	234.1 ± 125.6
Ferritin (ng/mL)	65.2 ± 55.6	70.7 ± 42.9	60.8 ± 57.1	48.7 ± 39.4

*A statistically significant difference ($P < 0.05$) between pre- and postexercise values. Values are represented as means ± STD of between 9 and 15 participants per group.
HDL—high density lipoprotein. LDL—low density lipoprotein. BF—body fat.

levels were measured. Serum ferritin levels were chosen as a measure of iron availability because approximately two-thirds of iron stored in the body is in the form of ferritin.[20] In addition, there is a direct relationship between ferritin and iron levels.[21–23] The current literature suggests that ferritin provides a sensitive, specific, and reliable measurement for determining iron deficiency at an early stage.[24] Our data demonstrate that there is little chance of iron deficiency caused by short term chromium picolinate supplementation and exercise. After 13 weeks of 1000 μg per day of chromium picolinate supplementation, ferritin levels were well above the 10 ng/mL indicative of iron deficiency anemia.[22] Together these data suggest that an exercise program plus chromium picolinate supplementation is an effective and safe addition to the armamentarium of cholesterol lowering regimens.

During the last two decades of this century it has become apparent that chromium is an essential component of human

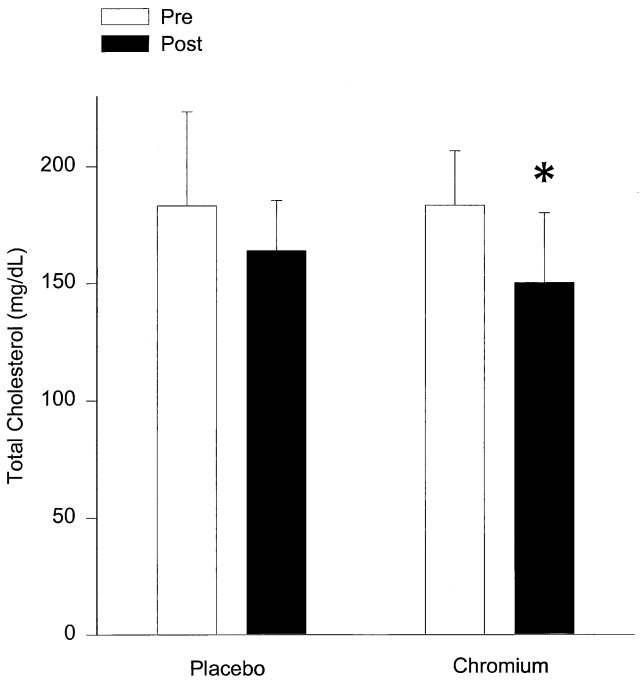

Figure 1 Total cholesterol concentration (mg/dL) for pre- (open bar) and postexercise (filled bar) chromium picolinate and placebo groups. Asterisk (*) represents a statistically significant difference ($P < 0.05$) between pre- and postexercise values. Values are represented as mean + STD of nine participants in each group.

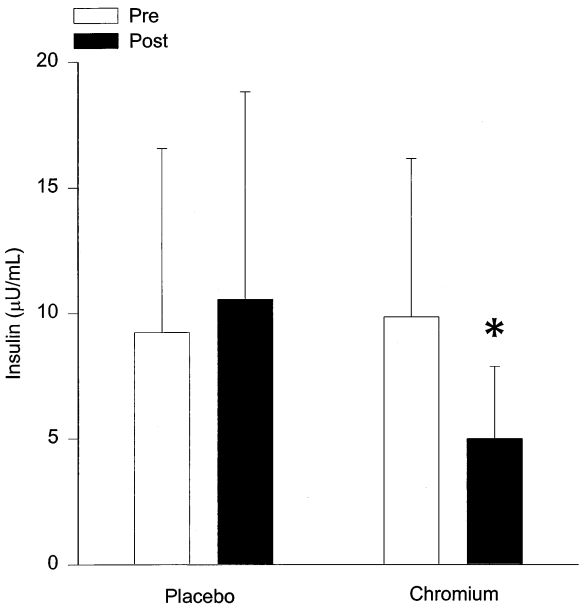

Figure 2 Insulin concentration (μU/mL) for pre- (open bar) and postexercise (filled bar) chromium picolinate and placebo groups. Asterisk (*) represents a statistically significant difference ($P < 0.05$) between pre- and postexercise values. Values are represented as mean + STD of nine participants in each group.

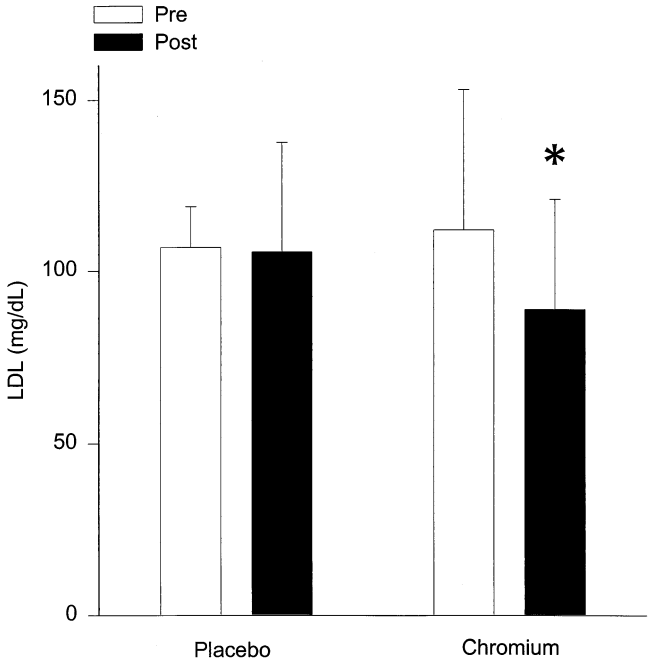

Figure 3 Low density lipoprotein (LDL) concentration (mg/dL) for pre- (open bar) and postexercise (filled bar) chromium picolinate and placebo groups. Asterisk (*) represents a statistically significant difference ($P < 0.05$) between pre- and postexercise values. Values are represented as mean + STD of nine participants in each group.

metabolism. Preliminary to our current work with dietary trivalent chromium supplementation in humans, the seminal studies of Schwartz and Mertz[25] showed that chromium is an essential nutrient in the diet of many animals. Recent studies in humans have demonstrated the efficacy of chromium supplementation in ameliorating, at least in part, the glucose intolerance associated with type II diabetes in some patients receiving total parenteral regimens deficient in chromium[3,26,27] and in some malnourished patients.[28,29] Studies in animals fed chromium deficient diets and in humans believed to be chromium deficient have enabled the establishment of a set of signs and symptoms of chromium deficiency that closely mimic those seen in type II diabetic patients.[30] These include impaired glucose tolerance, elevated circulating insulin, elevated urine glucose, fasting hyperglycemia, elevated serum lipids, increased atherosclerosis, neuropathy, decreased insulin sensitivity, and decreased insulin receptor number. It is important to realize that several studies[31,32] have shown no improvement in glucose tolerance and many of the other parameters listed above with dietary chromium supplementation. Furthermore, closer examination of many studies demonstrating improvements in patients receiving trivalent chromium reveals that the improvements are, although statistically significant, typically quite small. On the other hand, animals that are truly chromium deficient and malnourished humans predictably respond dramatically to chromium supplementation.

Such a discrepancy in findings has led some investigators[33] to hypothesize that there are perhaps at least two different syndromes of glucose intolerance: "true" type II diabetes and a chromium deficiency condition that closely mimics the classic type II diabetic constellation of signs and symptoms. Such a hypothesis remains to be evaluated and is only speculation at this point. Nonetheless, a careful examination of the literature does support the possibility of two separate physiologic processes with similar clinical presentations. Over the past several hundred years it is easy to find examples of nutritional deficiencies that have clinically mimicked the pathology of different diseases. For example, scurvy, Keeshan's disease, and beri-beri closely mimic their respective non-nutritional counterparts such as autoimmune collagen-vascular disease, congestive cardiomyopathy, peripheral and central neuropathologies, and peripheral myopathies. Although it is very appealing to envision curing or preventing the devastating cardiovascular, renal, ocular, and neural pathologies associated with noninsulin dependent diabetes mellitus with a simple dietary supplement such as chromium picolinate, current studies, including ours, do not support this. However, chromium may play a supportive role in treating diabetes and cardiovascular disease—pathologic processes that likely have at least several underlying etiologies that include an inappropriate diet, sedentary lifestyle, and obesity.

The health food and vitamin industries have increasingly advertised trivalent chromium as a panacea for a variety of ailments including glucose intolerance, high cholesterol, and obesity. Furthermore, some trivalent chromium producers and distributors imply that their chromium preparations will increase lean body mass, curb hunger, and increase the "energy" of the consumer. Although this may be true in some unique, small populations, our study shows only an effect on serum cholesterol, LDL, and insulin levels.

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