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EFFECTS OF CHROMIUM PICOLINATE SUPPLEMENTATION ON BODY COMPOSITION: A RANDOMIZED, DOUBLE-MASKED, PLACEBO-CONTROLLED STUDY

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ABSTRACT

To examine the effect of chromium picolinate (CrP) on body composition, a randomized, double-masked, placebo-controlled study was conducted. A total of 154 patients received either a placebo or 200 μg or 400 μg of CrP per day. Subjects were asked to consume at least two servings of a protein/carbohydrate nutritional drink a day that contained the different amounts of CrP. Subjects were free-living and were not provided with weight loss, dietary, or exercise guidance. Body composition was measured before and after the 72-day test period by using underwater testing (displacement method) with residual lung volumes determined by helium dilution. On completion of the posttest, a body composition improvement (BCI) index was calculated for each subject by adding the loss of body fat and gain in nonfat mass and subtracting fat gained and lean lost. Analysis of the prestudy data revealed that there were no significant differences in body composition between the three groups. After the test period, both the 200-μg and 400-μg groups had significantly higher positive changes in BCIs compared with placebo. A single-factor analysis of variance weighted linear trend was also highly significant. No significant differences in BCI were found between the 200- and 400-μg groups. Supplementation with a minimum of 200 μg/d of chromium (as CrP) can lead to significant improvement in body composition.

INTRODUCTION

Dietary chromium is an essential nutrient whose value in human nutrition has been conclusively documented.[1] Interest in chromium stems from the view that because chromium is an essential trace mineral and a cofactor (a substance with which another substance must unite in order for that second substance to perform a specific function or bring about a specific effect) to insulin, it could play an important role in glucose, lipid, and amino acid metabolism by its potentiating effects on insulin action.[2] Sup-

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porting this argument is the observation that chromium deficiency results in impaired glucose tolerance,[3,4] insulin resistance,[5] elevated blood glucose levels,[6] and symptoms of type II diabetes[7]; in addition, adequate amounts of physiologically active forms of chromium can reduce insulin requirements in humans.[8]

The National Academy of Sciences has classified chromium as an essential trace mineral and recommends daily intakes of 50 to 200 μg.[9] However, the most reliable studies report that intake among Americans is suboptimal—only 40% of the minimum for women and 60% for men.[10] These figures are similar to findings in England,[11] Finland,[12] and Canada,[13] and suggest a role for supplemental chromium. In fact, there are more than 25 human studies documenting the beneficial effects of supplemental chromium on subjects living at home including improvements in glucose, insulin, and lipid levels[14]; subjects with marginally impaired glucose tolerance; adults with elevated cholesterol levels; insulin- and noninsulin-requiring diabetic patients; and hypoglycemic patients.[1]

To increase the bioavailability of chromium, several studies[15–19] have suggested using picolinic acid, a naturally occurring metabolic derivative of tryptophan. Picolinic acid appears to combine with trace metal ions in the intestines and blood, which facilitates the collection and use of essential trace metals.[20] Thus combining picolinate acid with chromium in the form of chromium picolinate (CrP) should enhance the bioavailability of chromium[21] and, therefore, improve insulin utilization.

Because deposition of body fat appears to be regulated to some extent by insulin,[22] improvements in insulin utilization should lead to reductions in fat deposition. Enhancing the effects of insulin can also have positive effects on muscle tissue because insulin directs amino acids into muscle cells; once amino acids enter the muscle cells, they are assembled into proteins through insulin's effects on the cell's genetic material, that is, DNA and ribonucleic acid. Insulin also slows the breakdown, or catabolism, of body protein with a net effect of increasing the protein available for building tissue. Because chromium is a cofactor to insulin, supplemental chromium can potentially facilitate the maintenance or addition of fat-free mass (FFM).[23]

In addition, if CrP can lower insulin resistance it can improve body composition, as insulin resistance or deficiency results in impaired entry of glucose and amino acids into muscle cells and an increased catabolism of muscle protein as well as insulin deficiency's potential to accelerate lipid deposition.[24,25] However, at least one researcher[26] disagrees and hypothesizes that insulin resistance may help stabilize body fat in the obese patient, albeit at an obese level, acting much like a "set point" to prevent further weight gain.

In general, although animal studies have supported this contention,[18,27–32] one human study found positive changes in body composition

with CrP supplements,[33] another reported positive, although not statistically significant changes in body composition,[34] and a third failed to find any positive changes in body composition with CrP supplementation.[35] However, most human studies used small numbers of subjects, and subjects often followed exercise or conditioning programs that could increase the need for chromium at amounts higher than amounts provided in these studies.[1] Additionally, body composition has often been measured using indirect measures such as skinfold calipers.

We could not find any studies evaluating the efficacy of CrP using large numbers of free-living subjects (ie, subjects in whom no attempt is made to alter dietary or exercise habits) with beginning and ending body composition measurements evaluated using densitometry. This study was conducted to examine the effect of supplementation with CrP on improvement in body composition as measured by densitometry.

SUBJECTS AND METHODS

A total of 233 subjects were enrolled in the study and were tested, and 219 actually started: 44 men (mean age, 45.7 years) and 175 women (mean age, 46.5 years). Subjects were recruited from the first 233 volunteers who responded to a news story about the study run on the local Central Broadcasting System affiliate (KENS TV) in San Antonio, Texas. All subjects were asked to consult with their personal physician before signing the informed consent form.

Once subjects enrolled in the study and signed a standard informed consent, residual lung volumes were measured by an independent local pulmonary laboratory using a Collins Helium Dilution pulmonary functioning unit (Warren E. Collins, Inc., Braintree, Massachusetts). Underwater tests (displacement method) were conducted by the principal (GRK) investigator using a Whitmore Volumeter (Whitmore Enterprises, San Antonio, Texas) that correlates highly with hydrostatic weighing and has a test-retest reliability between 0.96 and 0.99.[36] A Detecto commercial platform scale (Model 8850, Detecto Scale Company, Webb City, Missouri) calibrated to 1/10 of a pound was used to obtain scale weights. Within 1 week of completing the tests, subjects were provided with their test results and randomly selected one of the precoded canisters containing the nutritional supplement and began the study.

Subjects were asked to consume at least two servings per day of the protein/carbohydrate drink base that we provided them for 60 days or until they completed their posttests, an average of 72 days. The drink base that contained 0, 100, and 200 μg of CrP was manufactured by Vitex Foods, Inc., Los Angeles, California, using a proprietary formula with 14 g of egg white protein and 10 g of carbohydrate (fructose) per serving. The manu-

facturer acted as trustee and coded each canister with the amount of CrP contained. None of the investigators, research technicians dispensing the product, or subjects knew which code corresponded to the amount of CrP in the canister. No dietary or exercise information was provided and subjects were asked to pursue whatever program they wished during the test period as long as they consumed at least two servings of the drink base each day for the next 72 days.

Subjects visited the research center every week to pick up another canister of the drink base and to obtain a scale weight. At the conclusion of the test period, subjects completed an ending body composition test and were asked to report how many servings of the drink base they actually consumed each day. All information was computerized and analyzed by the Department of Computing Research at the University of Texas Health Science Center-Houston, San Antonio, Texas, under the supervision of the second author (KB). Once the data on the three groups were analyzed, the trustee was contacted, and the coding information was released. The amount of CrP each subject consumed was calculated from their self-report of product usage.

The Criterion Measure—Body Composition Improvement

Because the efficacy of a weight loss product or program is best defined not as "weight" loss but rather the facilitation of fat loss while maintaining or increasing FFM, we calculated a body composition improvement (BCI) score for each subject that reflected positive or negative changes in body composition that occurred during the study. To calculate the BCI, losses in body fat and increases in FFM were added as positive changes and increases in body fat and decreases in FFM were added as negative changes. For example, a subject losing 2 pounds of body fat and gaining 1 pound of FFM would receive a BCI of +3 while a subject losing 2 pounds of fat but also losing 2 pounds of FFM would receive a BCI of 0. The decision to use the BCI was made before the study began and was based on the view that it is a more sensitive measure of change than percent of body fat and eliminates erroneous conclusions that are sometimes drawn by using either scale weight, body mass index, or percent body fat.[37]

Statistical Analyses

Statistical analysis of dropout rates was performed by using a chi-square test. All comparisons of means between the three groups were done using single-factor analysis of variance (ANOVA). In particular, the analysis of BCI changes was performed using single-factor ANOVA with three sets of a priori or planned mean contrasts that compared the two CrP groups versus placebo, the 400-μg group versus placebo and the 200-μg

group versus the 400-μg groups. The results of these planned contrasts are reported as probabilities of the pooled variance T statistic. Also, a test for a linear trend in the size of the means was obtained with a single-factor ANOVA. This test for linear trend is not used to compare differences between group means as was the ANOVA with the planned contrasts but merely to demonstrate the increasing size of the change in BCI associated with the dose of CrP. All statistical analyses were conducted using SPSS statistical software.

RESULTS

Table I provides the descriptive statistics for the 154 subjects who completed the study. A comparison of patients who did not complete the study with patients who did revealed that although the "dropouts" were significantly younger ($X = 40.0$, $P = 0.001$), there were no significant differences on any of the other body composition variables, including body weight, percent body fat, and body mass index.

Table II provides comparisons of the changes in body composition between groups. Using a planned contrast of group BCI means, an ANOVA revealed that the difference between the placebo and the 200-μg and 400-μg groups was significant at the $P = 0.015$ and $P = 0.0002$ levels, respectively. When the 200-μg and 400-μg groups were combined as a "CrP-supplemented group" and compared with the placebo group, the difference was significant at the $P = 0.0043$ level. The differences between the 200-μg and 400-μg groups were not significant. However, a single-factor ANOVA weighted linear trend for the BCI with all groups combined revealed a highly significant increasing trend ($P = 0.0002$) (figure).

DISCUSSION

Although examining tolerance or safety of chromium was beyond the scope

Table I. A comparison of entry demographic data for assessable subjects who were randomly selected into groups receiving a placebo or 200 μg/d or 400 μg/d of chromium picolinate for 72 days. Values are given as mean ± SD.

		Chromium Picolinate		
	Placebo (n = 55)	200 μg (n = 33)	400 μg (n = 66)	200 and 400 μg Combined (n = 99)
Age (y)	44.3 ± 11.2	45.9 ± 11.9	45.7 ± 11.8	45.8 ± 12.2
Body weight (kg)	83.3 ± 16.9	87.0 ± 16.8	85.3 ± 15.2	84.6 ± 17.8
Percent body fat	34.1 ± 8.4	34.5 ± 8.4	34.6 ± 8.2	34.6 ± 8.9
Body mass index (kg/m^2)	30.6 ± 5.5	30.3 ± 5.5	30.6 ± 5.1	30.5 ± 5.5

Table II. Comparisons of average changes in body composition variables between subjects receiving a placebo or 200 μg/d or 400 μg/d of chromium picolinate for 72 days. Values are given as mean ± SD.

		Chromium Picolinate		
	Placebo (n = 55)	200 μg (n = 33)	400 μg (n = 66)	200 and 400 μg Combined (n = 99)
Scale weight (kg)	−0.14 ± 2.66	−1.08 ± 3.42	−1.40 ± 2.93	−1.26 ± 3.01
Percent body fat	−0.3 ± 2.1	−1.4 ± 2.2	−1.9 ± 2.6	−1.7 ± 2.5
Fat weight (kg)	−0.18 ± 2.61	−1.62 ± 2.93	−2.07 ± 2.70	−1.89 ± 2.75
Nonfat weight (kg)	+0.09 ± 1.35	+0.54 ± 1.53	+0.68 ± 2.20	+0.63 ± 1.98
BCI (kg)	+0.27 ± 3.24	+2.16 ± 3.15	+2.75 ± 3.96	+2.57 ± 3.69

	t tests *P* values			
	Placebo vs 200 μg	Placebo vs 400 μg	Placebo vs 200 + 400 μg	200 μg vs 400 μg
Scale weight	0.15	0.016	0.022	0.60
Percent body fat	0.023	0.0003	0.0003	0.28
Fat weight	0.019	0.0002	0.0002	0.45
Nonfat weight	0.122	0.078	0.062	0.77
BCI	0.007	0.0003	0.0002	0.47

Note: Body mass index comparisons are not included because changes in body mass index are identical to changes in scale weight.
BCI = body composition improvement.

of this study, we found no evidence of toxicity in our review of the literature, particularly for the amounts used in this study. However, it should be clarified that the metallic form of chromium has nothing to do with the nutritional form. Chromium exists in two chemical states or valences, a term that refers to its ability to combine with other substances in chemical reactions. The metallic alloys and other industrial applications utilize hexavalent chromium (Cr^{+6}); the nutritional form is trivalent chromium (Cr^{+3}). Hexavalent chromium can be toxic, whereas trivalent or nutritional chromium has extremely low toxicity, probably about that of water.

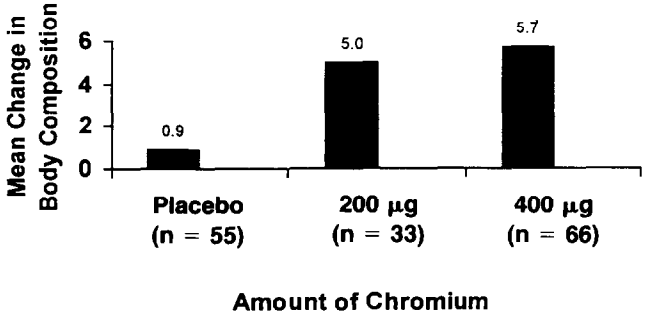

Figure. Single-factor analysis of variance weighted linear trend for subjects receiving placebo or 200 μg/d or 400 μg/d of chromium picolinate for 72 days. $P = 0.0002$.

Supplemental dietary CrP can improve body composition when a BCI is used to calculate total improvement in body composition based on depletion of body fat and maintenance or addition of FFM. Although the changes over a 72-day period were relatively small, they were statistically significant, particularly when data from subjects taking 200 μg/d of CrP are added to data from subjects taking 400 μg/d as a "CrP-supplemented group" and compared with changes occurring in the placebo control group. A comparison of the BCI between the 200-μg group and the 400-μg group revealed a larger BCI change in the 400-μg group, but the difference failed to reach statistical significance.

It is worth noting that the change in BCI in this study was virtually identical to the BCI change in one of the two studies using densitometry and where these calculations were possible based on the data the researchers provided.[34] Although identical, these changes in BCI were not statistically significant because of the small number of subjects these researchers had in each CrP-supplemented group versus the placebo group ($n = 8$ and $n = 9$, respectively). In the other study,[34] college-level football players participating in a 9-week spring training program were randomly divided into placebo ($n = 12$) and 200-μg CrP-supplemented ($n = 9$) groups and tested using densitometry before and after the training period. These researchers found no significant difference between the two groups. Although the exact pre- and poststudy body composition data were not provided, it does not appear that calculation of a BCI would alter their conclusions. Although they used a small number of subjects ($n = 21$) with a relatively high dropout rate (45%), the major difference in this study and the one we conducted is the type of subjects used, that is, athletes pursuing a training program versus free-living subjects.

Because several studies have shown strenuous physical activity increases urinary chromium loss,[27] it could be that 200 μg of CrP is too small an amount to produce positive changes in BCI when following a strenuous exercise program. A recent double-masked, placebo-controlled study of 40 collegiate swimmers[37] provides support for this contention.

In that study,[37] body composition (hydrodensitometry) measures were completed in the beginning, midway, and at the end of a 24-week period where the swimmers received either 400 μg/d of CrP or a placebo. Compared with the placebo group, the CrP group had significantly ($P < 0.05$) higher levels of lean body mass, lower levels of fat mass, and lower percentage body fat. These differences are even more pronounced when one applies the BCI calculation as discussed above. These researchers speculate that the effectiveness of CrP may require a longer supplementation period than is routinely used and when CrP is used in conjunction with high-intensity aerobic exercise.

Some concerns may be raised about the relatively high dropout rate in our study—69 of 219 (31.5%). An examination of the dropouts from the

study revealed that a virtually identical number from each group failed to complete the full protocol: 22 from the placebo group, 23 from the 200-μg group, and 24 from the 400-μg group. A comparison of their initial body composition scores revealed no significant difference between the three groups nor between any of the three groups of patients who completed or failed to complete the protocol. Poststudy discussions with some of the dropouts revealed that one of the principal reasons for dropping out was the relatively slow scale weight loss that occurred with many subjects in this study, particularly as some of the losses of body fat were masked by gains in FFM. Although the amount of the weight loss that occurred in this study could have long-term profound effects, few subjects were content with the relatively slow rate of weight loss. It has been our experience that it is difficult to maintain compliance when weight loss is gradual, particularly when fat depletion and gains in FFM may offset scale weight changes. Other contributing factors appear to have been the unpleasant nature of the underwater test and relatively long length (72 days) of the test period. Nonetheless, we have no reason to believe that the dropouts biased the final results.

CONCLUSION

These data suggest that supplementation with CrP can lead to significant improvements in body composition when a BCI is used as the outcome criterion that represents a sum of the net gains in nonfat mass added to the sum of the net losses of body fat.

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