Medicina Sportiva
Med Sport 16 (3): 99-103, 2012
DOI: 10.5604/17342260.1011388
ICID: 1011388

EFFECTS OF CHROMIUM PICOLINATE SUPPLEMENTATION ON BODY COMPOSITION IN IN-SEASON DIVISION I INTERCOLLEGIATE FEMALE SWIMMERS

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Abstract

Introduction: Chromium (Cr) supplementation has received anecdotal support for enhancing body composition. With this in mind, few studies have reported the effects of Cr supplementation in female athletes during a full competitive season.

Objective: To measure the effects of Cr picolinate (CP) supplementation on body composition in intercollegiate female swimmers over the course of a full competitive season.

Methods: Twenty female Divison I intercollegiate swimmers (19.5 ± 1.5 y, 64.8 ± 7.4 kg) participated in the double-blind study for a 26-week competitive season. Ten subjects received CP (400 $\mu g \cdot d^{-1}$) while 10 received a placebo (P). Total body mass (TBM), fat-free mass (FFM), fat mass (FM), and percent body fat (%BF) were measured using hydrodensitometry at baseline (PRE), 13 weeks (MID), and 26 weeks (POST).

Results: CP had a higher ($P = 0.008$) PRE-POST gain (vs. P) in FFM (2.2 ± 0.1 kg vs. 1.0 ± 0.2 kg), a higher ($P = 0.02$) PRE-POST % gain (vs. P) in FFM (4.6 ± 0.3% vs. 2.2 ± 0.6%), and a higher ($P = 0.006$) PRE-POST % loss (vs. P) in %BF (18.6 ± 0.9% vs. 11.9 ± 1.7%). In CP, PRE-MID, MID-POST, and PRE-POST there was a significant ($P = 0.047$ for all) decrease in TBM, FM, %BF, and an increase in FFM. In P, PRE-POST and MID-POST there was a significant ($P = 0.047$ for all) increase in FFM, and PRE-MID decrease in %BF.

Conclusion: Intercollegiate female swimmers supplementing in-season training with CP may increase FFM and decrease %BF.

Key words: *chromium, body composition, exercise, training*

Introduction

With athletes in general, decreased body fat or a higher lean mass is desirable for performance. Various nutritional products on the market make claims of stimulating muscle mass development. The majority of these products have been found in controlled research studies to have little or no effect on body composition. Chromium has received anecdotal support among athletes as having body composition enhancement capability [1-3]. It is purported that physical training causes a loss of urinary chromium, which may reduce chromium in athletes to below optimal levels [4], thereby reducing the ability for lean mass development.

Few studies have focused on chromium picolinate supplementation and body composition in athletes during a full competitive season. Most have been conducted using resistance training or low intensity aerobic training in untrained or obese subjects, or on pre-season training with athletes. Further, the duration of the majority of the research studies to test the efficacy of chromium picolinate supplementation has generally been 16 weeks or less [1,5,6]. Evans [5] conducted one of the first studies of chromium supplementation (200 $\mu g \cdot d^{-1}$) involving college males participating in 40 days of resistance training in a weight training class, twice per week, in a double-blind randomized design. Results showed a significant increase in lean mass (1.6 kg) and a slight increase (0.8%) in fat mass, versus only a slight increase in lean mass (1.25 kg) and a significant increase in percent body fat (1.1%) for the placebo group. In a second double-blind randomized design study reported by Evans in the same paper [5], collegiate football players who received chromium picolinate supplementation (200 $\mu g \cdot d^{-1}$) for 6 weeks while weight training four times per week showed a decrease in fat mass and an increase in lean mass compared to their placebo counterparts [5]. However, the validity of the results from the Evans studies is subject to question because of the accuracy of body composition determination through skinfold measurements. In a third study of chromium picolinate supplementation in males and females participating in weight training, females showed an increase in total body mass and fat free mass, while no changes were observed for males [6]. In another study, it was reported that 9 weeks of daily chromium picolinate supplementation (200 μg·d^{-1}) and weight training four times per week with collegiate football players did not increase muscle mass or muscle strength [1].

Most of the previous chromium supplementation studies have consistently shown no changes in body composition in response to exercise training. However, the majority of these have focused on body composition in response to resistance training in untrained subjects, trained subjects outside the competitive season, untrained or obese subjects using aerobic training protocols, and study durations of less than 16 weeks. Few, if any, studies have reported the effects of a combined intense resistive and aerobic in-season long-term training program with chromium supplementation on body composition for athletic populations. Therefore, limitations in previous studies warrant the investigation of the effects of chromium picolinate supplementation on body composition in highly-trained intercollegiate athletes during a competitive season. Therefore, the purpose of this study is to examine the effects of chromium picolinate supplementation on total body mass, lean mass, fat mass, and percent body fat in a group of female collegiate swimmers over the course of a full 26-week competitive season. Our hypothesis is that aerobic and resistance training coupled with chromium picolinate supplementation is more effective for improving body composition than aerobic and resistance training alone.

Methods

Subjects

Descriptive data for the subjects (mean ± SD) is presented in Table 1. Twenty female collegiate swimmers (19.5 ± 1.5 y, 64.8 ± 7.4 kg) participated in the study over the course of a 26-week competitive season. All subjects were in good health and screened using the standards set forth by the American College of Sports Medicine in the "Guidelines for Exercise Testing and Prescription."[20] Subjects were cleared for competition and the study by the team physician. All subjects read and signed informed consent documents as approved by the University institutional Review Board/Ethical Review Committee.

Table 1. *Subject characteristics (mean ± SD)*

Age (yr)	19.5 ± 1.5
Height (cm)	170 ± 7.5
TBM (kg)	64.8 ± 7.4
FFM (kg)	48.7 ± 5.5
FM (kg)	16.2 ± 3.5
%BF	20.2 ± 4.4

Three categories of swimmers (i.e. sprint, middle distance, and distance) were randomly divided into two equal cohort groups, chromium picolinate supplementation (CP) or placebo (P) in a double-blind manner. The groups were randomized by use of a standard random numbers table resulting in 10 subjects receiving CP, and the other 10 receiving P. Experimental mortality was 0. The tablets of CP and P were identical in color, texture, smell, and taste. Each day the subjects ingested either 400 μg of CP (Nutrition 21, Inc., Purchase, NY), or P (a mixture of dried tomatoes, broccoli, garlic, and flour), respectively. The CP pill was not composed of a base of the substances that made up the P pill. Each subject was asked to document food intake with a 3-day dietary recall. (See Dietary Analyses.) No other nutritional supplementation (i.e., over-the-counter vitamins) was permitted for the duration of the study. Any prescription medication was continued in the accustomed manner. Subjects received the treatment in bi-weekly installments. Compliance was measured by varying the number of capsules given to each subject and counting the number returned at the end of the assigned time period.

All subjects trained together for 26 weeks during the competitive season. Training was divided into weeks 1-8, weeks 9-22, and weeks 23-26. For weeks 1-8, the frequency of training was 6 days per week; for weeks 9-22, 7 days per week; and for weeks 23-26, 6 days per week. All subjects trained together in timed sets in the pool with respect to their swimming category. Training activities for weeks 1-8 included a 2 mile run, resistance training, flexibility exercises, and 2,800-3,700 m (3000-4,000 yd) of swim training. Resistance training included: upper-body isotonic training utilizing resistance training machines and free weights; abdominal crunches and lower-back extensions; upper- and lower-body plyometrics utilizing medicine balls, stair climbs, and box jumps; and in-water power training using a resistive power trainer. Training activities for weeks 9-22 included flexibility exercises, resistance training, and 11,000-15,000 m (12,000-16,000 yards) of swim training. For weeks 23-26, the amount of training, intensity, and frequency were reduced in order to produce a "tapering" effect for the conference championships. Average swimming meters per day during weeks 23-26 was reduced to approximately 3,000 with resistance training eliminated. The final week included the intercollegiate conference championships.

Body composition analyses

Results from hydrodensitometry were used to estimate fat-free mass, fat mass, and percent body fat. Residual volume (RV) was measured by the oxygen dilution technique [7]. Oxygen dilution was performed in triplicate with the subject being seated in the hydrostatic weighing tank submerged up to the neck and leaning slightly forward. Expired gas analysis was performed by a SensorMedics® 2900C metabolic cart utilizing the utilities function to obtain O_2 and CO_2 gas concentrations. The average of the three RV trials was used for Db calculations (where Db stands for body density). Hydrostatic weighing was performed on two consecutive days. Five trials each were completed with the average of trials 1, 2, and 4 from both days used for Db calculations [8,9]. Day-to-day variability was ± 0.000192 $g \cdot cc^{-1}$. Subjects were seated on a PVC chair suspended by tubular webbing in a cylindrical fiberglass tank 2 meters high by 1.5 meters in diameter. The chair suspension system was attached to a strain gauge calibrated to within ± 0.05 kg with a sensitivity of 0.01 kg. The strain gauge was connected to a load-cell and interfaced with an IBM computer via an RS232 port. The load-cell was equipped with peak value hold and the value was recorded by the computer. Percent body fat was calculated using the Siri equation [10].

Dietary analyses

Food intake diaries (Lifesteps® Weight Management Program, National Dairy Council, Rosemont, IL) were completed by the subjects for three consecutive days, during weeks 1-3 (baseline) and again during weeks 20-22 (comparison). Subjects received their diaries the afternoon prior to starting their 3 consecutive days. Subjects were instructed to complete the diaries at the end of each day (24 hr recall). Diaries were returned the morning following the third consecutive recall day. Subjects that were roommates did not complete the diaries during the same 3 day period. It should be noted that following week 22, subjects were encouraged by the head coach to increase dietary intake of carbohydrates to provide a "carbohydrate loading" effect for the conference championships. Diary information was analyzed by a computerized nutritional analysis software program (NutriCalc Plus®) to determine baseline nutritional status.

Statistical analyses

The data were analyzed with R, SAS, (SAS, South Carolina), and SPSS software. Descriptive characteristics (mean±SD) were determined for age, height, total body mass (TBM), fat-free mass (FFM), fat mass (FM), and percent body fat (%BF). Three time points were used in the study: baseline (PRE), 13 weeks (MID), and 26 weeks (POST). Preliminary analysis showed that the data might not be normally distributed, and thus Exact Wilcoxon tests were used to compare the dependent variables (TBM, FFM, FM, and %BF) across time (PRE-MID, MID-POST, PRE-POST) within each group (CP and P). Exact Wilcoxon tests were also used to compare net changes and percentage changes in the dependent variables, for both PRE-MID and PRE-POST between groups (CP and P).

The Bonferroni method for multiple comparisons was used for all tests. For comparing the net changes and percentage changes between groups (CP and P), we used a Bonferroni correction factor of 8 for 4 responses (TBF, FFM, FM, %BF) * 2 time comparisons (PRE-MID, PRE-POST). For the comparisons across time points within each group, we used a Bonferroni correction factor of 24 for 4 responses (TBF, FFM, FM, %BF) * 3 time comparisons (PRE-MID, MID-POST, PRE-POST) * 2 groups (P and CP). Throughout this paper, all reported *P*-values represent *P*-values with the Bonferroni correction.

Results

The primary focus of the study was to evaluate the effects of chromium supplementation on body composition (i.e. TBM, FFM, FM, and %BF) at three time points (i.e. PRE, MID, and POST) during the competitive season for intercollegiate female swimmers. Respective data (mean ± SE) in response to CP supplementation or P are presented in Table 2.

There were three significant differences between groups in body composition across the duration of the study. First, CP had a higher PRE-POST gain (kg) vs. P in FFM (2.2 ± 0.1 kg for CP, vs. 1.0 ± 0.2 kg for P, $P = 0.008$). The CP also had a higher PRE-POST percentage gain in fat-free mass (4.6 ± 0.3% for CP and 2.2 ± 0.6% for P, $P = 0.02$). Finally, the CP group had a higher PRE-POST percentage loss in %BF (18.6 ± 0.9% loss for CP, and 11.9 ± 1.7% loss for P, $P = 0.006$).

Table 2. *Total body mass (TBM), fat-free mass (FFM), fat mass (FM), and percent body fat (%BF) in female swimmers across 26 weeks of a competitive season with chromium picolinate supplementation (CP) or placebo (P) (mean ± SE)*

	P			CP		
Variable	PRE	MID	POST	PRE	MID	POST
TBM (kg)	64.5 ± 2.5	62.6 ± 2.3	61.6 ± 2.2	65.1 ± 2.2	63.6 ± 2.2	61.9 ± 2.2
FFM (kg)	48.7 ± 1.8	49.2 ± 1.6	49.7 ± 1.6	48.6 ± 1.7	49.5 ± 1.8	50.8 ± 1.8
FM (kg)	15.9 ± 1.1	13.7 ± 0.8	12.4 ± 0.5	16.5 ± 0.9	14.1 ± 0.9	11.1 ± 0.8
%BF	20.1 ± 1.4	18.8 ± 1.2	17.6 ± 1.1	20.3 ± 1.5	18.9 ± 1.3	16.4 ± 1.1

There were several significant changes within groups in body composition across the duration of the study. In CP, from PRE-MID, MID-POST, and PRE-POST there was a significant ($P = 0.047$ for all) decrease in TBM, FM, %BF, and an increase in FFM. In P there was a significant ($P = 0.047$ for all) PRE-POST and MID-POST increase in FFM, and a PRE-MID decrease in %BF. There were no significant changes across time for P in TBM or FM.

Discussion

To our knowledge, this is the first reported study to determine the effects of chromium supplementation on the body composition of highly trained athletes during a competitive season. The results suggest that CP intake (400 $\mu g \cdot d^{-1}$) for 26 weeks coupled with intensive resistance and aerobic training with taper promotes significant positive changes in body composition versus training alone. These changes determined via hydrodensitometry occurred during the 26 weeks of the competitive season. As hypothesized, chromium supplementation significantly increased fat-free mass and decreased percent body fat in the CP group versus the P group.

These results are in contrast to other athletic populations receiving chromium supplementation. Other studies have found no difference in body composition in response to chromium supplementation in football players, intercollegiate wrestlers, and softball players [1]. These investigations differed from the current study in one or more of the following: shorter lengths of study were used; subjects were in the off-season; smaller amounts of chromium supplementation were involved; skinfold measurements to determine body composition were employed; subjects were not highly trained; an intense training component was lacking. The current design attempted to account for these and other limitations by conducting a longer term, randomized, double-blind study with placebo in highly trained athletes, using hydrodensitometry to determine body composition, and by incorporating intense in-season aerobic, anaerobic, and resistive training. We speculate that any or all of these factors could affect body composition responses to chromium supplementation in exercising athletic populations.

The literature suggests that urinary chromium losses may be linked to exercise intensity, degree of fitness, and chromium supplementation [1,4,12-15]. Anderson and colleagues [12] found daily urinary Cr excretion of trained subjects to be higher on the day of a single exercise bout at 90% $\dot{V}O_2max$ compared with nonexercise days. Rubin et al [15] determined that acute and chronic (i.e. 16 weeks of) resistive training increased urinary Cr losses in those consuming a diet in compliance with the American Heart Association while improving the insulin response, increasing fat-free mass, and decreasing percent body fat. The authors further concluded that Cr metabolism and exercise both lead to improved glucose and insulin metabolism and to improved body composition, with the likelihood that some of the improvements due to exercise are related to increased Cr absorption. Insulin sensitivity and glucose response are generally enhanced by chromium; yet neither insulin nor glucose was measured in the present study. Therefore the mechanisms driving glucose and insulin response in the present study are purely speculative. Cr supplementation may have compensated for suspected Cr loss over the course of the season. In conclusion, to better determine the effects of chromium supplementation and intense training, measurements of carbohydrate metabolism, insulin, and body composition would provide additional insight into the mechanisms involved.

To our knowledge, this is the first study to report body composition responses for chromium supplementation with intense training in intercollegiate athletes over a full competitive season. Others have reported no significant changes in body composition in collegiate athletes in response to chromium supplementation with pre-season exercise training. For example, in 1994, in a double-blind, randomized design with intercollegiate football players, Clancy et al. [1] reported no changes in body composition or muscular performance with increased urinary chromium excretion in response to 9 weeks of 3 $d \cdot wk^{-1}$ off-season resistance training, 2 $d \cdot wk^{-1}$ of running training, and 200 $\mu g \cdot d^{-1}$ chromium supplementation. Further, in a double-blind design and random assignment of 200 $\mu g \cdot d^{-1}$ chromium supplementation or placebo in Division I collegiate wrestlers, Walker et al [16] reported no changes in body composition or muscular performance in response to 14 weeks of 3 $d \cdot wk^{-1}$ pre-season resistance training. In a similar fashion in a double-blind, randomized design with intercollegiate Division I female softball athletes, Livolsi [17] found no changes in body composition or strength in response to 6 weeks of 3$d \cdot wk^{-1}$ pre-season resistance training with 500 $\mu g \cdot d^{-1}$ of chromium supplementation. However, chromium excretion was found to be increased in the chromium group versus baseline and placebo. In a review, Vincent [18] in 2003 finds no pattern in statistically significant changes from study to study in body composition with exercise training and chromium supplementation.

In the present study, in order to control the timing of training so that it coincided with the performance season, all training was administered during the competitive season and monitored by the coaches. All coaches were unaware of which athletes were receiving chromium supplementation or the placebo. The resistance training program contained the same number of sets and relative intensities across athletes. Overall swim distance and timed cycles were the same across CP and P; however, it must be noted that there was no control over the individual times for the training sets in the pool. In a study of intercollegiate male and female competitive swimmers over a 12-week season, Siders et al. [19] found that in females better swimming performance (decreased time) in short distance events was associated with a higher fat-free weight and lower body fatness. However, there were no significant relationships for body composition and swim performance for the male swimmers. These results suggest avenues for future work might consider associations of body composition and performance times for swimming specific stroke events and distances.

In conclusion, these results suggest that 6 months of chromium picolinate 400 $\mu g \cdot d^{-1}$ supplementation in intercollegiate female swimmers during a competitive season coupled with high intensity aerobic, anaerobic, and resistive workouts had positive effects on body composition. These include increasing fat-free mass and lowering percent body fat versus placebo. We conjecture that the effectiveness of chromium supplementation is dependent on dosage, training status, mode and intensity of training, and duration of supplementation. As mentioned earlier, other studies in athletic populations were conducted for periods of time less than 26 weeks (the duration of the present study). Therefore, we postulate that it takes at least 3 months for fat-free mass and percent body fat to respond favorably to chromium picolinate supplementation versus placebo for female swimmers during a competitive season. Results from the present study suggest that female competitive swimmers who supplement in-season training with 6 months of chromium picolinate (400 $\mu g \cdot d^{-1}$) may increase their fat-free mass and decrease their percent body fat versus training alone. Future studies should investigate the effects of chromium picolinate supplementation on the body composition of trained competitive male swimmers. Future work may also consider this type of supplementation in other competitive sports with similar types of training where similar changes in body composition are desired.

Acknowledgements

This study was funded by an internal Wright State University Research Challenge Award.

Declaration of interest

The authors report no conflicts of interest.

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Accepted: September 15, 2012
Published: September 25, 2012

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A – Study Design	C – Statistical Analysis	E – Manuscript Preparation	G – Funds Collection